

EXHIBIT 2

IN THE UNITED STATES COURT OF FEDERAL CLAIMS

In re DOWNSTREAM ADDICKS
AND BARKER (TEXAS) FLOOD-
CONTROL RESERVOIRS

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)
)
) Sub-Master Docket No. 1:17-9002L
)
)
) Hon. Loren A. Smith
)

DECLARATION OF DR. PHILIP BEDIENT

I, Dr. Philip Bedient, in accordance with 28 U.S.C. § 1746 hereby declare:

1. I have a Ph.D. (1975) in Environmental Engineering Sciences from the University of Florida, an M.S. (1972) in Environmental Engineering from the University of Florida, and a B.S. (1969) in Physics from the University of Florida.

2. I am the Herman Brown Professor of Engineering in the Department of Civil and Environmental Engineering at Rice University, where I have served since 1975. From 1992 to 1999, I served as Chair of Environmental Engineering at Rice University. In 2006, I was elected as a Fellow to the American Society of Civil Engineers (“ASCE”).

3. I teach and perform research in surface water hydrology, groundwater hydrology, floodplain analysis, flood prediction systems, coastal resiliency and disaster management, and storm water quality control. I have directed 60 research projects over the past 40 years. A full copy of my CV is attached as an Exhibit to my declaration.

4. It is my professional opinion, based on reasonable engineering judgment, that the U.S. Army Corps of Engineers’ (Corps) design and construction of the Addicks and Barker dam facilities, combined with the Corps’ decision to release induced surcharges far in excess of the carrying capacity of the connecting Buffalo Bayou

tributaries and outlets as required by the Corps' 2012 operations manual, was a significant and producing cause of property damage to the 192 properties represented in this Response to Order to Show Cause. Had the Corps followed its pre-2012 operating procedures, which required the Corps to retain storm water until it could be released at rates that were within the carrying capacity of Buffalo Bayou and its outlets, or had the Corps completed improvements to Buffalo Bayou channels to increase their carrying capacity up to 15,000 cubic feet per second (cfs) as the project was originally designed and authorized, these Stayed Plaintiffs would have suffered far less flooding, if any.

5. In short, it is my opinion that the 2017 flood damage to the Stayed Plaintiffs' properties was the direct, proximate and intended result of the Corps' decisions regarding the design, construction and operation of the Addicks and Barker dams, resulting in the Corps' release of about 15,000 cfs during late August and early September, 2017, instead of continuing to store the rainfall runoff from Harvey within the available storage capacity of the dams for later release at a time that would not have caused damaging flooding to Stayed Plaintiffs' properties.

HARVEY RAINFALL WAS NOT UNFORESEEN BY THE CORPS

6. Based on NWS and Harris County records, between 30 and 35 inches of rain fell over the Addicks and Barker Reservoir watersheds during Harvey, from August 25 to August 29, 2017. The heaviest rains fell during the three-day period from August 26-28. Even more rain fell over other parts of the Houston area, especially on the eastern portions of Harris County.

7. This 30+ inches of rain is less than the amount of rain that fell in Alvin,

Texas from Tropical Storm Claudette in 1979, during which 43 inches of rain fell in a period of 24 hours (ref. Corps' 2009 Master Plan). Alvin is about 40 miles southeast of the Addicks and Barker Reservoirs. Similarly, during Tropical Storm Allison in June 2001, 36 inches of rain fell over portions of northeast Harris County over a 5-day period. Allison was centered 50 miles northeast of Addicks and Barker (USACE016098). Thus, the 30+ inches of Harvey rainfall in the Addicks and Barker watersheds were less than other heavy tropical storm events that had previously occurred in the Houston area.

8. In addition, this Harvey rainfall was also much less than what was used by the Corps to redesign the Addicks and Barker Dams and their spillways in the 1980s (being about 45 inches of rain in three days) (USACE016345). Thus, the Harvey rainfall over the Addicks and Barker watersheds was clearly foreseeable and predictable, as a much larger amount of rain had been foreseen and designed for by the Corps.

ORIGINAL DESIGN OF ADDICKS AND BARKER DAMS/RESERVOIRS (1940s)

9. In response to the historic flooding in downtown Houston during the 1929 and 1935 floods, Congress authorized the Buffalo Bayou & Tributaries ("BB&T") flood control project for the protection of the City of Houston and the Houston Ship Channel, in the June 20, 1938 River and Harbor Act (as modified by the Flood Control Acts of 1939 and 1954). The Addicks and Barker Dams were constructed in the 1940s about 15 miles west of the city limits of Houston, as part of this BB&T flood control project, along with the construction of 7.4 miles of channel improvements immediately downstream from these two dams along the bayou that were intended to carry non-damaging releases from the dams. Additionally, authorized channel projects further downstream that were

part of the BB&T project to safely carry flows of 15,000 cfs or more from the dams to Galveston Bay were never constructed.

10. These two dams were originally designed and constructed to be large detention basins, with 4 uncontrolled and 1 controlled (gated) outlet conduits at each dam, with the intent that these dams would capture and store rainfall runoff from the upper portions of the Buffalo Bayou watershed while slowly releasing flood waters at non-damaging rates downstream into Buffalo Bayou. Both dams were designed exclusively for flood control; the reservoirs are typically dry, detaining water only during significant storms (USACE016308).

11. These two dams were designed to be capable of capturing and storing the rainfall runoff from the probable maximum storm expected in the Houston area at that time, which was determined to be about 30 inches of rain in 72 hours (the “Design Storm”). [It should be noted that T.S. Harvey dumped about the same amount of rain over the watersheds of these two dams.] During such a storm, the combined maximum outflows through the 4 uncontrolled outlets from each of these two dams was designed to be about 15,000 cfs, which according to the design could then be carried by the channel improvements downstream of the dams without overflowing its banks. But this goal was never realized, as only part of the downstream channel improvements was ever constructed, severely limiting the carrying capacity of Buffalo Bayou.

UPDATED DESIGN (1980s)

12. By the early 1980s the Corps realized that, given updated rainfall data for the Houston area, the occurrence of a major storm that would cause catastrophic failure

of these dams was NOT considered a remote possibility, noting that in 1979 T.S. Claudette had just occurred within 40 miles of the Addicks and Barker dams (dumping 43 inches of rain in 24 hours) and would have resulted in overtopping of these dams with probable failure if it had occurred over the Addicks and Barker watersheds (USACE570696). The Corps stated that the new Probable Maximum Storm (estimated to be 43 inches in 3 days) “is considered a probable occurrence when compared with the 1979 Claudette rainfall event which occurred some 40 miles to the south of the reservoirs,” (USACE 487625-26). This new rainfall data, combined with new dam safety criteria, led the Corps to re-evaluate the design and operation of the Addicks and Barker dams.

13. In its 1984 General Design Memorandum, the Corps acknowledged that the Addicks and Barker dams are now potential safety hazards under present day standards and do not meet current Corps’ dam safety criteria (USACE485995). They noted that due to the current non-damaging capacity of the downstream channel along Buffalo Bayou, the combined releases from both reservoirs was now limited to 2,000 cfs less any inflows from tributaries (USACE485997). This report by the Corps evaluated certain alternatives for addressing the dam safety issue at these two dams and identified the ultimately adopted solution to be raising the middle portion of the dam embankments and armoring the ends to now serve as emergency spillways. The construction of these dam modifications was completed by the late 1980s (USACE314492).

14. At Addicks, the lowest spillway was constructed on the northern portion of the dam at an elevation of about 112 feet (NAVD 88). The government-owned land

extends to about 103 feet (NAVD 88) within Addicks Reservoir. The new Maximum Design Pool for Addicks Dam/Reservoir has been identified by the Corps to now be 115 feet (NAVD 88), much higher than the original maximum design pool, and higher than the maximum pool reached during Harvey (i.e., 109.1 feet). The dam was redesigned and reconstructed to handle much more rainfall than what fell during Harvey without having any concerns for the structural integrity of the dam.

15. At Barker, the concrete-lined emergency spillways at each end of the dam were constructed at an elevation of about 105-106 feet (NAVD 88). The government-owned land extends to about 95 feet (NAVD 88) within Barker Reservoir. The new Maximum Design Pool for Barker Dam/Reservoir has been identified by the Corps to now be 108 feet (NAVD 88), much higher than the original maximum design pool, and higher than the maximum pool reached during Harvey (i.e. 101.6 feet). The dam was redesigned and reconstructed to handle much more rainfall than what fell during Harvey without any concerns for the structural integrity of the dam.

16. Acquisition of real estate by the government, both upstream and downstream of the dams, was based on the original design (USACE016335). Even though the dams were redesigned and reconstructed during the 1980s to store far more water to handle a much larger storm event for the new Maximum Design Storm than the original 30 inches of rain, the Corps did not make an effort to acquire more private property as part of the government-owned land, or to acquire flowage easements over any private property, either upstream or downstream. The Corps recognized the potential for upstream reservoir impacts, stating in the 2012 Water Control Manual that “pool levels in

excess of Government-owned land will damage residential developments adjacent to Government-owned lands,” (USACE016335).

RE-EVALUATION OF OPERATING PROCEDURES (1990s- 2009)

17. Since the Corps had addressed the concerns about dam safety with the modifications that had been constructed at these two dams in the late 1980s, there was no longer a need for any Emergency Operations schedule allowing for damaging releases for any storm within the facility’s design capacity. However, the Corps was still concerned about the lack of real estate acquisition both upstream of the dams and downstream of the spillways where flooding issues were now of considerable concern.

18. In 1992, and again in 1995, the Corps conducted a study on Addicks and Barker Reservoirs about ways to address these flooding issues given the compromised operation of these dams in limiting releases to non-damaging rates along Buffalo Bayou (USACE314492; USACE015108). The Corps first noted that the existing plan for reservoir regulation is to operate these dams “in a manner that will prevent damaging stages on downstream Buffalo Bayou. This is accomplished by utilizing, to the maximum extent possible, the available storage capacity within the reservoirs. This is in keeping with the original primary objective of flood control for the Addicks and Barker Reservoirs. Since a downstream portion of the project was never completed, the flow rate must be restricted to 2,000 cfs to preclude damages to downstream properties along Buffalo Bayou,” (USACE314499). Furthermore, the Corps reiterated that “this significantly impacts allowable release rates from the reservoirs. If flooding is predicted or reported downstream, the gates will be closed. The gates will remain closed until the

downstream conditions permit system releases plus local inflows that remain below non-damaging capacity,” (USACE314500). The above described operations and procedures prolong the storage of floodwaters in Addicks and Barker Reservoirs and require longer periods of time to complete the release of these stored floodwaters (USACE015135).

19. In October 2009, the Corps and its local sponsor (the Harris County Flood Control District) conducted another operational assessment of these two dams (USACE464067). This evaluation again noted that dam operations require that the gates remain shut even if pool levels increase and flood upstream properties (USACE464090). Thus “during a flood event, the gates are closed, and reservoir levels are allowed to rise until they overflow the spillways,” (USACE464103).

UPDATED WATER CONTROL MANUAL (2012)

20. But in 2012 the Corps reversed course and revised its water control operations (USACE016290). For the first time, in this 2012 Water Control Manual, the Corps introduced the concept of “Induced Surcharge” as part of its Water Control Plan (Sect. 7–03.b. – USACE016336).

21. Section 7–05 of this new manual, entitled “Flood Control,” continued the existing requirement to close the gates at the beginning of the storm, but then provided a new section entitled “Induced Surcharge Flood Control Regulations” applicable when the reservoir pools reached about 45% of the facilities’ storage capacity (which is well below the level of the emergency spillways). If the inflows and pool elevation conditions dictated use of these induced surcharge regulations, the Dam Operator was to release water from the dams regardless of the limits of downstream channel capacity

(USACE016408). That is, once the reservoirs were about half full, the Corps was to release flows that it knew would overtop Buffalo Bayou and flood Stayed Plaintiffs' properties.

22. This revised 2012 Water Control Manual included a set of inundation maps along Buffalo Bayou downstream of the dams for flow rates ranging from 3,000 cfs up to 20,000 cfs (USACE016426–30). It also included the “Induced Surcharge Operations Schedule” for both Addicks and Barker dams in Plates 7-03 and 7-04, respectively (USACE016435-36). These schedules provide for releases from these two dams even without any concerns about dam safety issues, allowing combined releases up to about 15,000 cfs starting at pool elevations of 101 feet NAVD 88 in Addicks and 95.8 feet NAVD 88 in Barker (USACE016435–36). This compares to the elevation of Government-owned lands (GOL) in Addicks at 103 feet (with the emergency spillway at 112 feet) and in Barker at 95 feet (with the emergency spillway at 105-106 feet) (USACE016402). These “Induced Surcharge Operations Schedules” have a cap of about 15,000 cfs on combined releases once the pool elevations reach 108.6 feet (NAVD 88) in Addicks and 103.6 feet (NAVD 88) in Barker, as compared to the elevations at the natural ground at the ends of the dams of 108 feet for Addicks and 104 feet for Barker.

DOWNSTREAM FLOODING DURING HARVEY

23. During Harvey, the Addicks and Barker Dams were operated by the Corps by closing the floodgates in compliance with its 2012 Water Control Manual (USACE016338). In doing so, the Addicks and Barker Dams captured the incoming flood and storm waters from the Harvey rainfall and stored them behind/upstream of the

dams, as planned and intended by the Corps. Once the pool levels rose above 45 percent capacity, rising above the Federal Government-Owned Lands and beginning to flood upstream private properties, the Corps began to open its floodgates at both Addicks and Barker dams early in the morning of August 28, 2017, eventually reaching a discharge of up to 15,000 cfs into a channel whose capacity was no more than 3,000 cfs. The result was significant flood damage to Plaintiffs' properties that would not have occurred if the Corps had just left the floodgates closed until the water could safely be released, as had been the previous operating procedure. This flooding of the downstream properties was a man-made situation directly resulting from the Corps' redesign, reconstruction, and its new 2012 operation requirements for Addicks and Barker dams. Never had these dams released flood damaging flows downstream during a flood event.

24. At Addicks, the pool elevation at which induced surcharges are released is 103 feet (NAVD 1988, 2001 adj.), and the elevation of the emergency spillways are at about 112 feet (USACE019883). The maximum pool elevation that was reached during Harvey within the Addicks Reservoir was about 109.1 feet (NAVD 1988, 2001 adj.), about 6 feet lower than the Maximum Design Pool elevation of 115 feet, and 3 feet below the spillway (USACE016689). This pool elevation of 109.1 feet occurred on August 30, before the pool began to recede as the outflows from the dam exceeded the inflows (USACE016689). Addicks Dam thus had substantial remaining storage capacity below the spillway available—enough to store the waters accumulated from Harvey without releasing damaging flows from the floodgates.

25. At Barker, the pool elevation at which induced surcharges are released is 95

feet (NAVD 1988, 2001 adj.), and the emergency spillway elevation is about 105-106 feet (USACE019885). The maximum pool elevation that was reached during Harvey within the Barker Reservoir was about 101.6 feet (NAVD 1988, 2001 adj.), about 6.5 feet lower than the Maximum Design Pool elevation of 108 feet, and about 4 feet below the emergency spillways (USACE016689). This maximum pool elevation of about 101.6 feet occurred on August 30, before the pool began to recede as the outflows from the dam exceeded the inflows (USACE016689). Like Addicks Dam, Barker Dam also thus had substantial remaining storage capacity below the spillway available—enough to store all of the waters accumulated from Harvey without releasing damaging flows from the floodgates.

26. Releases from Addicks and Barker dams started early on the 28th of August and reached their peak flow rates of about 15,000 cfs on August 30th. These releases continued for about a week before significant reductions in the releases occurred. Prior to reaching the maximum releases from Addicks and Barker reservoirs on August 30, the rains had stopped. Any flooding of the Plaintiffs' properties on the 30th of August 2017 (depicted in publicly available aerial photos) and thereafter was due solely to the releases from these dams and not from local inflows.

27. Computer modeling by the Government's expert Dr. Nairn showed that had the gates at Addicks and Barker dams not been opened during Harvey, there would have been significant reductions in the maximum flood levels and duration of flood levels that occurred downstream along Buffalo Bayou, including at the majority of the Test Properties. The same would be expected for the named Plaintiffs in this Response.

FORESEEABILITY OF HARVEY FLOODING FOR DOWNSTREAM PROPERTIES AND INEVITABILITY OF RECURRING FLOODING

28. The amount of rainfall that fell during Harvey over the watersheds of Addicks and Barker Dams/Reservoirs was foreseeable. Harvey produced about 30+ inches of rain over a 3-5 day period that fell across these watersheds. This amount of rain was easily foreseeable and was not unprecedented relative to other storms that hit this part of Texas (indeed the Corps designed Addicks and Barker to handle even more water than fell during Harvey). As stated above, back in 1979, Tropical Storm Claudette dropped more than 40 inches of rain in 24 hours in Alvin, Texas, which is just 40 miles southeast of Addicks and Barker. Also, Tropical Storm Allison in 2001 dropped about 35 inches of rain in five days over portions of northeast Harris County. The Corps discussed these two tropical storm events and recognized that if they had occurred over the watersheds of Addicks and Barker Dams/Reservoirs, the pool levels would have exceeded the government-owned land, inundated private property, and possibly exceeded the capacity of the Addicks and Barker dams (USACE016098–16100 (ref. Corps’ 2009 Master Plan)). Additionally, on April 18, 2016 (the so-called Tax Day flood), the Addicks and Barker watersheds actually received between 10-17 inches of rain during a 24-hour period (USACE207227). This rainfall caused new record pool elevations in both Addicks and Barker, causing streets in the upstream neighborhoods to be inundated by the reservoir flood pool for the first time (USACE207227). Thus, not only did two huge storms miss the Addicks and Barker watersheds, but another huge storm hit the watersheds just sixteen months prior to Harvey—all underscoring the inevitability of

future storms that will cause flooding onto private property under the Corps' current design, construction and operation of these dams.

29. In addition, the rainfall from Harvey was reasonably anticipated, based on the storm events mentioned above. That is why the Corps raised the dam walls in the 1980s, significantly increasing the Maximum Design Pool to store far greater volumes of water beyond what Harvey dropped. All large dams in Texas since the 1970s are designed based on the Probable Maximum Precipitation (PMP), which in this Houston area is about 45 inches of rain in 24 hours, far more than occurred during Harvey (USACE016345).

30. The flood damage of the downstream property owners was both inevitable and man-made. The flooding of Plaintiffs' properties downstream of the dams during Harvey was the direct, natural and probable result of the redesign, reconstruction and changed operation of the Addicks and Barker Dams/Reservoirs and was intended by the Corps, pursuant to its 2012 Water Control Manual.

31. Due to the existence of the Addicks and Barker Dams/Reservoirs, and the heavy storms that come through this part of Texas, future flooding of the private property that lies below the dams is, as a factual matter, inevitable. This remains true so long as the Corps operates Addicks and Barker under the induced surcharge provisions of its 2012 operations manual. Although the dams have been designed to store water behind them during significant rain events like Harvey, the Corps' 2012 operations manual requires them to release damaging flow rates through the floodgates at levels far below the maximum design pool, and even below their emergency spillways—intentionally

flooding Stayed Plaintiffs' properties. The Maximum Design Pool elevation is based on managing a rainfall of over 40 inches in three days, far greater than what occurred during Harvey. And, severe rainfall and heavy storms are common in this part of the Texas coast, especially associated with tropical storms and hurricanes.

32. Further, my review of the relevant documents confirms that the Corps foresaw the flooding of downstream property owners. In its 2012 Water Control Manual, the Corps included flood profiles and flood maps showing the extent of flooding for releases up to 20,000 cfs along Buffalo Bayou, including showing the slab elevations of known houses. In the days immediately before Harvey, the Corps made predictions about the inevitability of the flooding upstream of Addicks and Barker dams, knowing that the pools would not get up to the emergency spillways. Specifically, I have reviewed the CWMS reports produced by the Corps, which show that the Corps predicted in the days before Harvey that the floodwaters would exceed the federal government-owned land and impact private property, but would not get over the spillways (USACE005862–006024). In short, the Corps' own predictions in 2012, and up to the hours immediately before Harvey, underscore the continued foreseeability and inevitability of future flooding.

33. Finally, the Corps could have operated the dams under its 2012 manual's induced surcharge provisions without causing flood damage downstream if it had only acquired the land and constructed the improved channels necessary to carry the 15,000 cfs as the project was originally authorized and designed. For many years, the Corps has attempted to address the flooding risk to the private property located downstream of the Addicks and Barker Reservoirs (USACE015134–015137 (ref. 1995 Section 216

Reconnaissance Report)).

34. The Corps considered purchasing private land in fee simple, or condemnation of flowage easements, that would allow for much higher releases downstream safely (USACE015136– 015137). The Corps rejected these options; rather, the Corps decided to assume the risk of flooding and the risk of litigation (USACE015137; USACE015148). When in 2012 the Corps changed its operating manual to require releases far beyond the non-damaging capacity of Buffalo Bayou and its outlets, without acquiring any additional real estate, the Corps knew the Stayed Plaintiffs would face inevitable recurrent flooding of their properties.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on: June 10, 2020



Dr. Philip Bedient

**APPENDIX OF DOCUMENTS REFERENCED IN THE
DECLARATION OF DR. PHILIP BEDIENT**

| Exhibit No. | Description | Document Bates No. |
|--------------------|--|--|
| 1 | Curriculum Vitae of Dr. Philip Bedient | N/A |
| 2 | 2009 Master Plan | USACE016047 USACE016098-16100 |
| 3 | 2012 Water Control Manual | USACE016290 USACE016308 USACE016335-16339 USACE016345 USACE016402 USACE016408 USACE016426-016430 USACE016435-016436 |
| 4 | 1984 General Design Memorandum | USACE485914 USACE485995-485997 |
| 5 | 1979 Nov 26 Letter Report | USACE570696 |
| 6 | Feb. 13, 1984, Consideration of Alternatives for Preserving Integrity of Addicks & Barker Reservoirs Embankments (Note re PMS a probable occurrence) | USACE487625-487626 |
| 7 | 1992 Special Report on Flooding, Buffalo Bayou & Tributaries, Texas, Addicks & Barker Reservoirs, May 1992 | USACE314492 USACE314499-314500 |
| 8 | 1995 Reconnaissance Report, Section 216 Study, Addicks and Barker Reservoirs | USACE015108 USACE015134-015137 USACE015148 |
| 9 | 2009 Draft Operational Assessment of the Addicks and Barker Reservoirs, Fort Bend and Harris Counties, TX | USACE464067 USACE464090 USACE464103 |
| 10 | 2014 Emergency Action Plan, Addicks Reservoir and Barker Reservoir | USACE019755 USACE019883 USACE019885 |
| 11 | Memorandum for Commander, Southwestern Division, Subject: Addicks and Barker Dams, Houston, Texas, New Pool of Record; October 27, 2017 | USACE016689 |
| 12 | 2016 Report of Performance, Addicks Barker Dams, New Pool of Record; May 11, 2016 | USACE207226-207227 |
| 13 | CWMS Forecasts during Harvey | USACE005862-006024 |

Exhibit 1

January 2020

Philip B. Bedient, Ph.D., P.E.
Curriculum Vitae

ADDRESS:

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P.B. Bedient and Associates, Inc.
13910 Wilde Forest Court
Sugar Land, TX 77498

EDUCATION:

B.S. Physics, University of Florida, Gainesville, Florida, 1969
M.S. Environmental Engineering, University of Florida, 1972
Ph.D. Environmental Engineering Sciences, University of Florida, 1975

PROFESSIONAL EXPERIENCE:

Chair – Department of Civil and Environmental Engineering, Rice University, Houston, TX –
July 2019 to present
Herman Brown Professor of Engineering - Civil and Environmental Engineering - Rice
University - July 2001 to present.
Professor - Environmental Engineering - Rice University - 1986 to 2001.
Professor and Chair - Department of Environmental Science and Engineering, Rice University,
Houston, Texas, 1992 - 1999.
Associate Professor - Environmental Engineering – 1980 - 1986.
Assistant Professor - Environmental Engineering – 1975 - 1980.

SCIENTIFIC SOCIETIES:

American Society of Civil Engineers
American Institute of Hydrology
American Water Resources Association
Association of Environmental Engineering Professors
American Academy of Water Resources Engineers
American Geophysical Union

HONORS:

Diplomate - Water Resources Engineer, American Academy of Water Resources Engineers
(2008)
C.V. Theis Award from the American Institute of Hydrology (April 2007)
Fellow – American Society of Civil Engineers (April, 2006)
Endowed Chair – Herman Brown Professor in Engineering (July, 2001)
Shell Distinguished Chair in Environmental Science (1988-93)
Phi Beta Kappa

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Curriculum Vitae

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PROFESSIONAL COMMITTEES:

Expert Panel – “Impacts of Climate Change on Transportation Systems and Infrastructure in the Gulf Coast” USDOT and USGS, 2005 - 2006

TS Allison Recovery Project - Technical Advisory Committee - 2002-2003

Harris County Flood Control District - Brays Bayou Federal Project Com – 1998- 2002

National Academy of Engineers (National Research Council) 2

Committee on DoE Environmental Management Technologies (CEMT) - 1995-96

Committee on In-Situ Bioremediation - 1992-93

UNIVERSITY COMMITTEES:

Dean Review Committee – Department of Architecture, 2019

Undergraduate Curriculum Committee, 2005-2019

Accreditation (ABET/SACS) Committee, 2005-2019

Events and Reception Committee (Chair) 2012

Mentorship Committee 2012

Space Planning Committee, 2005-2019

CEE Student-Group Advisors 2012

BSCE Advisor 2007-2019

Center for Civic Engagement Committee, 2007-2012

Parking Committee, 1998-2012

Search Committee, Civil and Environmental Engineering, (2001-2002)

Chair, Dean of Engineering Search Committee, (1988)

Computer Committee, Athletics Committee, 1998-2000

Advisory Council, School of Engineering

LICENSES:

Professional Engineer, State of Texas, Environmental Engineering (45626)

Professional Hydrologist, American Institute of Hydrology

RESEARCH INTERESTS:

Flood & Surge Mitigation

As the director of the Severe Storm Prediction Center (SSPEED) at Rice University (since 2007) Dr. Bedient leads a team of five universities and 15 investigators from Gulf Coast universities dedicated to improving storm prediction, education, and evacuation from disaster. The Center was approved by the Texas Legislature and has been funded at over \$9.0 million for 8 years from the Houston Endowment (Hurricane Ike Lessons Learned and Future Steps). A book, “Lessons from Hurricane Ike” was published by TAMU press in June 2012. The SSPEED Center has taken a unique approach to surge mitigation by addressing in bay residual surge impacts related to hurricanes in the Gulf.

Flood Alert Systems with Radar

The development of a real-time flood ALERT system (FAS4) for Brays Bayou and the Texas Medical Center in Houston, TX has been completed. The FAS4 currently uses NEXRAD radar for application to flood prediction and real-time flood alert systems. TMC, FEMA, and TXDOT funded FAS improvements from 1998 thru 2010. Analysis of the severe storm impacts in urban watershed areas has been completed using radar rainfall data, combined with GIS techniques for digital terrain and hydraulic modeling in Houston and other coastal areas in Texas. The system worked perfectly during Harvey in Houston.

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Curriculum Vitae

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Flood Analysis and Mapping

Monitoring and modeling of radar rainfall and associated hydrology using standard models such as HEC-HMS and HEC-RAS as well as distributed models such as VFLO (VAI). These models have been used to model watersheds all over the U.S. and in flood related legal cases. These models are currently being used for assessing impacts from Hurricane Harvey, the largest measured rainfall in U.S. history over a 5 day period.

Hazardous Waste Site Evaluation

Monitoring and modeling of waste plumes associated with 35 hazardous waste sites nationally. Identification of extent of contamination, transport mechanisms, and control strategies. MODFLOW and RT3D modeling of transport and aquifer restoration using withdrawal-treatment and microbial degradation methods. Analysis of hazardous waste sites in California, Texas and Florida.

COURSES and STUDENTS:

- CEVE 412 - Hydrology and Watershed Analysis
- CEVE 512 - Hydrologic Design Laboratory
- CEVE 101 - Fundamentals of Civil and Environmental Engineering
- CEVE 415/515 - Water Resources Planning and Management (50%)
- 20 Ph.D. and 70 M.S. degrees since 1975

RESEARCH STATEMENT:

Dr. Philip B. Bedient is also Herman Brown Professor of Engineering in the Dept of Civil and Environmental Engineering at Rice University. He teaches and performs research in surface and ground water hydrology, disaster management, and flood prediction systems. He served as Chair of Environmental Engineering from 1992 to 1999. He has directed 60 research projects over the past 42 years, has written over 180 articles in journals and conference proceedings. He is lead author on a text on "Hydrology and Floodplain Analysis" (Prentice Hall, 6th ed., 2018, to appear) used in over 75 universities across the U.S. Dr. Bedient received the Herman Brown endowed Chair of Engineering in 2002 at Rice University. He was elected to Fellow ASCE in 2006 and received the prestigious C.V. Theis Award from the American Institute of Hydrology in 2007. He earlier received the Shell Distinguished Chair in Environmental Science (1988 to 1993).

He is the director of the Severe Storm Prediction Center (SSPEED) at Rice University (since 2007) consisting of a team of seven universities and 15 investigators from Gulf coast universities dedicated to improving storm prediction, education, and evacuation from disaster. The Center was approved by the Texas Legislature and is currently funded by the Houston Endowment (Hurricane Ike Lessons Learned and Future Steps). A book has been developed and published by TAMU press titled "Lessons from Hurricane Ike" published in June 2012. The SSPEED Center has taken a zone approach to developing mitigation strategies and has identified four zones of interest in the Houston-Galveston region: the Houston Ship Channel, West Bayshore, Galveston Island and a Coastal Recreation Area.

Dr. Bedient has over 40 years of experience working on flood and flood prediction problems in the U.S. He has evaluated flood issues in Texas, California, Florida, Louisiana, and Tennessee. He has worked on some of the largest and most devastating floods to hit the U.S. including the San Jacinto River flood of 1994, T.S. Frances in 1998, T.S. Allison in 2001, Hurricane Katrina in 2005, Hurricane Rita in 2005, Hurricane Ike in 2008, and the Nashville, TN flood of 2010. He is currently involved in the analyzing three major floods in Houston, 2015, 2016, and Harvey in 2017. He routinely runs computer models such as

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Curriculum Vitae

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HEC-HMS, HEC-RAS, SWMM, and VFLO for advanced hydrologic analysis. He developed one of the first radar based rainfall flood alert systems (FAS-3) in the U.S. for the Texas Medical Center.

The SSPEED Center has put on a number of conferences, meetings, and training courses since 2007. Prominent national speakers have been invited to these conferences, which include attendees from academia, industry, consulting, and emergency managers. These conferences provide a forum for public discussion and response for decision and policy makers, and stakeholders. As a result of this work, we have received a large number of Rice News stories over the past several years, in the form of both video interviews with the media as well as newspaper coverage.

Dr. Bedient has been involved in the technology transfer area for more than two decades through the teaching of short courses for government, university, and private sectors. He has recently organized five conferences on Severe Storm flooding and recovery projects in 2001, 2003, and 2005, 2006, and 2007 on the Rice University campus. In 2008 he organized a new major conference on "Severe Storms Prediction and Global Climate in the Gulf Coast" in October 2008 which hosted speakers who experienced first hand the impacts of both hurricanes Katrina and Ike. SSPEED is now moving its research mission to address post-Harvey impacts and had a conference in FEB 2018. **(over 2500 media hits since Harvey).**

SURFACE WATER PROJECT (since 1990):

"Measuring, Mapping and Managing Flood Risk: A Pilot Program in Texas" – Texas A&M University, \$160,000, January 2019 – December 2020

"Cypress Creek Watershed Analysis of Flooding & Storage Options" - Greater Houston Flood Mitigation Consortium, \$121,912, September 2018 – April 30, 2019

"Greens Bayou Watershed Analysis and Resiliency Planning GHFMC Proposal" - Greater Houston Flood Mitigation Consortium, \$233,088, August 2018 – November 2019

"Center to Rebuild Texas" TAMU and the Governor's Office. \$175,000, April 2018 – July 2019.

"Analysis of Federal Project Residual Flood Areas" Greater Houston Flood Consortium, \$130,000, Jan – Aug 2018.

"FAS4 - Operational Support" – Texas Medical Center, \$96,000 per year, Oct 2017 – present
Flood Warning System for White Oak Bayou, funded by Kinder Inst at Rice U. \$75,000 for 2017-18.

"SSPEED Center Proposal to the Houston Endowment -- Environmental Studies of Various Gal Bay Surge Mitigation Strategies, 2017-2019", Houston Endowment, \$1,000,000.

Shell Center Award (Padgett and Bedient) -- \$50,000 for one year. 2015-2016.

NSF PIRE award "Coastal Flood Risk Reduction Program: Integrated, Multi-scale Approaches for Understanding how to Reduce Vulnerability to Damaging Events, (2015-2020), \$100,000 per year for 5 years shared with Jamie Padgett. (50%). (Dutch Exchange Program for students).

Shell Center Award "Stress Nexus of Coastlines: Population Development, Infrastructure Security, and Morphological Dynamics of the Upper Texas Gulf Coast" (2014-2016). With others (\$20,000).

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“SSPEED Center Proposal to the Houston Endowment 2014-2017,” Houston Endowment \$3,200,000. Last year funding level of \$500,000.

“SSPEED Center Proposal to the Houston Endowment Coastal Integrated”, Houston Endowment, 2011-2014, \$3,195,451

“FAS3- Operational Support”, Texas Medical Center, 2012-2017, \$96,000 per year for 5 years. Supports the operation and research related to TMC Flood Alert System Analysis

“Urban Resilience: Flooding in the Houston-Galveston Area”, Kinder. 2009-2012, \$240,003

“White Oak Bayou BMP Demonstration Project – Cottage Grove Subdivision”, City of Houston, 2009-2013, \$165,000.

“Residential Storm Surge Damage Assessment for Galveston County”, Texas General Land Office (GLO), 2012-2013, \$100,000

“Rice University FEMA: Food Analysis”, Rice, 2011-2012, \$70,000

“Amendment to Expand Development and Validation of the Online Storm Risk Calculator Tool for Public Usage”, City of Houston, 2011, \$388,030

“Hurricane Ike: Lessons Learned and Steps to the Future”, Houston Endowment, 2009-2012, \$1,250,000

“Libya AEL Training Grant”, AECOM, 2008-2010. \$1.7 million over 2 years.

“Texas OEM SSPEED Training” University of Texas, 2008, \$90,000

“Watershed Information Sensing and Evaluation System”. Houston Endowment (with UH), 2007-2010, \$400,000.

“Advanced Flood Alert System for the TXDOT for Bridge Control at 288”. HGAC, 2007-2011 \$200,000.

“Civil and Environmental Engineering for the 21st Century”. NSF Dept Reform Grant, 2005-2007, \$100,000.

“CASA – Collaborative Adaptive Sensing of the Atmosphere – the Houston Testbed”. NSF, 2003 – 2009, \$110,000, (\$90,000 for 2006-07).

“FAS2 - Operational Support”, Texas Medical Center, 2003-2012, \$69,000.

“Flood Alert System (FAS2) for the Texas Medical Center and Brays Bayou”. FEMA, 2002-2003, \$300,000.

“Multi-Purpose Water Management Technology for the Texas Mexico Border”, Advanced Technology Program, 2000-2001, \$129,000.

“Analysis of Clear Creek Watershed,” Galveston Bay Preservation Foundation, 1999-2000, \$15,000.

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“Flood Alert System - Maintenance and Support”. Texas Medical Center, 1998-2002, \$271,000.

“Flood Prediction System for the Texas Medical Center”. Texas Medical Center, 1997-1998, \$262,000.

“The Effects of Changing Water Quality and Market Inefficiencies on Water Resource Allocation in the Lower Rio Grande Valley”. Energy and Environmental Systems Institute, Rice University, 1996-1997, \$12,000.

"Characterization of Laguna Madre Contaminated Sediments", Environmental Protection Agency, 1995, \$68,500.

"Role of Particles in Mobilizing Hazardous Chemicals in Urban Runoff". Environmental Protection Agency, 1992-95, \$240,000. (P. B. Bedient, Co-P.I.).

"Galveston Bay Characterization Report", Galveston Bay National Estuary Program, 1991-1992, \$35,000.

"Characterization of Non-Point Sources and Loadings to Galveston Bay". Galveston Bay National Estuary Program, 1990-1991, \$125,000.

GROUNDWATER PROJECTS (SINCE 1990):

“A Large-Scale Experimental Investigation of the Impact of Ethanol on Groundwater Contamination”, (P.J.J. Alvarez – Co-P.I.) American Petroleum Institute, 2004-2007, \$120,000.

“A Large-Scale Experimental Investigation of Impact of Ethanol on Groundwater Contamination”, Gulf Coast Hazardous Substances Research Center, 2004-2005, \$45,000.

“A Large-Scale Experimental Investigation of Impact of Ethanol on Groundwater Contamination”, Gulf Coast Hazardous Substances Research Center, 2003-2004, \$95,000.

"Chlorinated Solvent Impact and Remediation strategies in the Dry Cleaning Industry”, Gulf Coast Hazardous Substances Research Center, 2000 – 2003, \$149,400.

"Design Manual for the Extraction of Contaminants from Subsurface Environments", Environmental Protection Agency, 1994-2002, \$4,500,000.

"Development of Data Evaluation/Decision Support System for Bioremediation of Subsurface Contamination", Environmental Protection Agency, 1993-1996, \$450,000.

Shell Distinguished Chair in Environmental Science, Shell Oil Company Foundation, 1988-1993, \$750,000.

LIST OF HAZARDOUS WASTE SITE PROJECTS (since 2000):

2001 The Dickson County Landfill, Dickson, TN

2002 Celanese Engineering Resins, Inc., Bishop, TX

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2002 GB Biosciences, Houston, TX

2003 DOW Plaquemine, LA

2004 Ciba-Geigy, McIntosh, AL

2004 Amoco, Independence, MO

2004 Olin-Geigy, McIntosh, AL

2006 Crazy Horse Landfill, Monterey County, CA

2008 Mid-Valley Sanitary Landfill, Rialto, CA

2010 Pratt-Whitney, West Palm Beach, FL

2013 Monsanto, Mystic River, MA

2013 San Jacinto River Waste Pits, San Jacinto River, TX

2015 LCP Chemicals Site, Brunswick, GA

2015 North Carolina Steam Stations, NC

PUBLICATIONS AND PRESENTATIONS

A. Books or Related Chapters

1. **Bedient, P. B. and Huber, W. C. (2018). "Hydrology and Floodplain Analysis", 6th Ed. Pearson, January 2018, 760 pages.**
2. Fang, Z., Sebastian A., and Bedient, P.B. 2014. "*Modern Flood Prediction and Warning Systems.*" Handbook of Engineering Hydrology: Fundamentals and Applications (Chapter 21), Vol. 1, Taylor & Francis Inc. ISBN-10:1466552417.
3. Bedient, P. B. and W. C. Huber, 2012, "*Hydrology and Floodplain Analysis*", 5th Ed. Prentice-Hall Publishing Co., Upper Saddle River, NJ, February 2012, 800 page textbook.
4. Bedient, P. B., 2012 "*Lessons learned from Hurricane Ike*" Ed. Philip Bedient. College Station, TX: Texas A&M University Press, College Station, TX: 2012, 194 Pages.
5. Rifai H.S., Borden R.C., Newell C.J. and Bedient P.B., "*Modeling Remediation of Chlorinated solvent plumes*" In Situ Remediation of Chlorinated solvent Plumes, Chapter 6, H.F. Stroo, C.H. Ward Editors, Springer, N.Y. 2010, 145 pp.
6. Fang, Z., Safiolea, E., Bedient, P.B. (2006) "*Enhanced Flood Alert and Control Systems for Houston.*" In Chapter 16, Coastal Hydrology and Processes, Ed. By Vijay P. Singh and Y. Jun Xu, Water Resource Publications, LLC, pp. 199-210.
7. Capiro, N.L. and Bedient P.B. "*Transport of Reactive Solute in Soil and Groundwater*" The Water Encyclopedia (2005): 524-531.

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8. Horsak, R.D., Bedient, P.B., Thomas, F.B., and Hamilton, C. "*Pesticides*", Environmental Forensics (2005).
9. Thompson, J.F. and Bedient, P.B. "*Urban Storm Water Design and Management*," The Engineering Handbook, Chapter 94, CRC Press, 2004, 21 pp.
10. Bedient, P. B., Rifai H. S., and Newell C. J., "*Ground Water Contamination: Transport and Remediation*", 2nd Ed. PTR Publ., Upper Saddle River, NJ, 1999, 605 pages.
11. Charbeneau, R. J., Bedient, P. B. and Loehr R. C., "*Groundwater Remediation*", Technomic Publishing Co., Inc., Lancaster, PA 1992, 188 pages.

B. Peer Reviewed Journal Publications (since 1990, out of a total of 165)

1. Gori, A., Gidaris, I., Elliott, J., Padgett, J., Loughran, K., Bedient, P., Panakkal, P., and Juan, A. "Accessibility and Recovery Assessment of Houston's Roadway Network due to Fluvial Flooding during Hurricane Harvey." Natural Hazards Review, Vol. 21, Issue 2 (2019/May). DOI: doi:10.1061/(ASCE)NH.1527-6996.0000355.
2. Gori, A., Blessing, R., Juan, A., Brody, S., & Bedient, P. "Characterizing urbanization impacts on floodplain through integrated land use, hydrologic, and hydraulic modeling." Journal of Hydrology, 568(2019/January): 82-95. DOI: 10.1016/j.jhydrol.2018.10.053.
3. Bernier, C., Kameshwar, S., Elliott, J. R., Padgett, J. E., & Bedient, P. B. (2018). Mitigation strategies to protect petrochemical infrastructure and nearby communities during storm surge. Natural Hazards Review, 19(4) doi:10.1061/(ASCE)NH.1527-6996.0000309
4. Bass, B., Torres, J. M., Irza, J. N., Proft, J., Sebastian, A., Dawson, C., & Bedient, P. (2018). Surge dynamics across a complex bay coastline, Galveston bay, TX. Coastal Engineering, 138, 165-183. doi:10.1016/j.coastaleng.2018.04.019
5. Bass, B., & Bedient, P. (2018). Surrogate modeling of joint flood risk across coastal watersheds. Journal of Hydrology, 558, 159-173. doi:10.1016/j.jhydrol.2018.01.014
6. Anarde, K. A., Kameshwar, S., Irza, J. N., Nittrouer, J. A., Lorenzo-Trueba, J., Padgett, J. E., . . . Bedient, P. B. (2018). Impacts of hurricane storm surge on infrastructure vulnerability for an evolving coastal landscape. Natural Hazards Review, 19(1) doi:10.1061/(ASCE)NH.1527-6996.0000265
7. Brody, S. D., Sebastian, A., Blessing, R., & Bedient, P. B. (2018). Case study results from southeast Houston, Texas: Identifying the impacts of residential location on flood risk and loss. Journal of Flood Risk Management, 11, S110-S120. doi:10.1111/jfr3.12184
8. Bernier, C., Elliott, J. R., Padgett, J. E., Kellerman, F., & Bedient, P. B. (2017). Evolution of social vulnerability and risks of chemical spills during storm surge along the Houston Ship Channel. Natural Hazards Review, 18(4) doi:10.1061/(ASCE)NH.1527-6996.0000252
9. Torres, J.M., Bass, B., Irza, J.N., Proft, J., Sebastian, A., Dawson, C., and Bedient, P (2017). Modeling the Hydrodynamic Performance of a Conceptual Storm Surge Barrier System for the Galveston Bay Region. J. of Waterway, Port, Coastal, and Ocean Engineering. DOI: 10.1061/(ASCE)WW.1943-5460.0000389.
10. Bass, B., Juan, A., Gori, A., Fang, Z., and Bedient, P. (2016). 2015 Memorial Day Flood Impacts for Changing Watershed Conditions in Houston, TX. Natural Hazards Review. DOI: 10.1061/(ASCE)NH.1527-6996.0000241.

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11. Juan, A., Hughes, C., Fang, Z., and Bedient, P., 2016. Hydrologic Performance of Watershed-scale Low Impact Development (LID) in a High Intensity Rainfall Region. *Journal of Irrigation and Drainage Engineering*, doi: 10.1061/(ASCE)IR.1943-4774.0001141.
12. Torres, J., Bass, B., Irza, N., Fang, Z., Proft, J., Dawson, C., Kiani, M., and Bedient, P (2015). Characterizing the hydraulic interactions of hurricane storm surge and rainfall-runoff for the Houston-Galveston region. *Coastal Engineering* 106, 7-19. DOI: <http://dx.doi.org/10.1016/j.coastaleng.2015.09.004>.
13. Juan, A, Fang, Z., and Bedient, P.B. "Developing a Radar-Based Flood Alert System for Sugar Land, Texas." *Journal of Hydrologic Engineering* (2015).
14. Brody, S.D., Sebastian, A., Blessing, R., & Bedient, P.B. (2015). Case-study results from southeast Houston, Texas: Identifying the impacts of residential location on flood risk and loss. *Journal of Flood Risk Management*, (accepted for publication). doi: 10.1111/jfr3.12184
15. Fang, N., Dolan G., Sebastian, A., & Bedient, P.B. (2014). Case Study of Flood Mitigation and Hazard Management at the Texas Medical Center in the Wake of Tropical Storm Allison in 2001. *ASCE Natural Hazards Review*, 15(3). doi: 10.1061/(ASCE)NH.1527-6996.0000139.
16. Christian, J, Fang, Z., Torres, J., Deitz, R. and Bedient, P.B. "Modeling the Hydraulic Effectiveness of a Proposed Storm Surge Barrier System for the Houston Ship Channel during Hurricane Events." *Natural Hazards Review* 16, no. 1 (2014): 04014015
17. Burleson, Daniel W., Hanadi S. Rifai, Jennifer K. Proft, Clint N. Dawson, and Philip B. Bedient. "Vulnerability of an industrial corridor in Texas to storm surge." *Natural Hazards* 77, no. 2 (2015): 1183-1203.
18. Sebastian, A., Proft, J., Dawson, C., & Bedient, P.B. (2014). Characterizing hurricane storm surge behavior in Galveston Bay using the SWAN+ADCIRC model. *Coastal Engineering*, 88, 171-181. doi: <http://dx.doi.org/10.1016/j.coastaleng.2014.03.002>.
19. Brody, S.D., Blessing, R., Sebastian, A., & Bedient, P.B. (2014). Examining the impact of land use/land cover characteristics on flood losses. *Journal of Environmental Planning and Management*, 57(8), 1252-1265. doi: 10.1080/09640568.2013.802228.
20. Brody, S.D., Blessing, R., Sebastian, A., and Bedient, P.B. (2013). "Delineating the Reality of Flood Risk and Loss in Southeast, TX." *ASCE Natural Hazards Review*, 14, 89-97. doi: 10.1061/(ASCE)NH.1527-6996.0000091.
21. Fang, Z., Sebastian A., and Bedient, P.B. 2014. "Modern Flood Prediction and Warning Systems." *Handbook of Engineering Hydrology: Fundamentals and Applications* (Chapter 21), Vol. 1, Taylor & Francis Inc. ISBN-10:1466552417.
22. Teague, A., J. Christian, and P. Bedient. (2013) "Use of Radar Rainfall in an Application of Distributed Hydrologic Modeling for Cypress Creek Watershed, Texas". *Journal of Hydrologic Engineering*. DOI: 10.1061/(ASCE)HE.1943-5584.000056.
23. Doubleday, G., Sebastian, A., Luttenschlager, T., and Bedient, P.B. (2013). "Modeling Hydrologic Benefits of Low Impact Development: A Distributed Hydrologic Model of The Woodlands, TX." *Journal of American Water Resources*, 1-13. doi: 10.1111/jawr.12095.
24. Christian, J., A. Teague, L. Dueñas-Osario, Z. Fang, and P. Bedient, (2012). "Uncertainty in Floodplain Delineation: Expression of Flood Hazard and Risk in a Gulf Coastal Watershed." *Journal of Hydrological Processes*, doi: 10.1002/hyp.9360.

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25. Ray, T., Stepinski, E., Sebastian, A., Bedient, P.B. (2011) "Dynamic Modeling of Storm Surge and Inland Flooding in Texas Coastal Floodplain", Journal of Hydraulic Engineering, ASCE, Vol. 137, No.10, October 2011, ISSN 0733-9429/2011/10-1103-1110
26. Fang, Z., Bedient, P. B., and Buzcu-Guven, B. (2011). "Long-Term Performance of a Flood Alert System and Upgrade to FAS3: A Houston Texas Case Study". Journal of Hydrologic Engineering, ASCE Vol. 16, No. 10, October 1, 2011, ISSN 1084-0699/2011/10-818-828.
27. Teague, A., Bedient, P. and Guven, B. (2010). "Targeted Application of Seasonal Load Duration Curves using Multivariate Analysis in Two Watersheds Flowing into Lake Houston" (JAWRA-10-0003-P.R1). Journal of American Water Resources Association. Accepted.
28. Fang, Z., Zimmer, A., Bedient, P. B., Robinson, H., Christian, J., and Vieux, B. E. (2010). "Using a Distributed Hydrologic Model to Evaluate the Location of Urban Development and Flood Control Storage". Journal of Water Resources Planning and Management, ASCE, Vol. 136, No. 5, September 2010, ISSN 0733-9496/2010/5-597-601.
29. Fang, Z., Bedient, P. B., Benavides J.A., and Zimmer A. L. (2008). "Enhanced Radar-based Flood Alert System and Floodplain Map Library". Journal of Hydrologic Engineering, ASCE, Vol. 13, No. 10, October 1, 2008, ISSN 1084-0699/2008/10-926-938.
30. Gomez, D. E., De Blanc, P. C., Rixey, W., Bedient, P.B., Alvarez, P. J.J. (2008), "Evaluation of Benzene Plume Elongation Mechanisms Exerted by Ethanol Using RT3D with a General Substrate Interaction Module" Water Resource Research Journal, Vol. 44, May.
31. Rifai, H.S., Borden, R. C., Newell, C. J., and Bedient, P.B. "Modeling Dissolved Chlorinated Solvents in Groundwater and Their Remediation," in SERDP monograph on Remediation of Dissolved Phase Chlorinated Solvents in Groundwater, (accepted) 2007.
32. Bedient, P. B., Holder, A., and Thompson, J. F., and Fang, Z. (2007). "Modeling of Storm water Response under Large Tailwater Conditions – Case Study for the Texas Medical Center". Journal of Hydrologic Engineering, Vol. 12, No. 3, May 1, 2007.
33. Capiro, N.L., Stafford, B.P., Rixey, W.G., Alvarez, P.J.J. and Bedient, P.B. "Fuel-Grade Ethanol Transport at the Water Table Interface in a Pilot-Scale Experimental Tank" Water Research, 41(3), pp. 656-654, 2007.
34. Bedient, P.B., Rifai, H.S., Suarez, M.P., and Hovinga, R.M. "Houston Water Issues" Chapter in Water for Texas. Jim Norwine and J.R. Giardino, Eds. pp. 107-121, 2005.
35. Characklis, G.W., Griffin, R.C., and Bedient, P.B. "Measuring Long-term Benefits of Salinity Reduction" Journal of Agricultural and Resource Economics, 30 (1) (2005): 69-93.
36. Bedient, P.B., Horsak, R.D., Schlenk, D., Hovinga, R.M., and Pierson, J.D. "Environmental Impact on Fipronil to Louisiana Crawfish Industry" Environmental Forensics (2005): 289-299.
37. Characklis, G. W., Griffin, R.C., and Bedient, P.B. "Measuring the Long-term Benefits of Salinity Reduction" Journal of Agricultural and Resource Economics, 30(1), pp.69-93, 2005.
38. Vieux, B.E. and Bedient, P.B. "Assessing urban hydrologic prediction accuracy through event reconstruction" Journal of Hydrology, 299(3-4), pp. 217-236. Special Issue on Urban Hydrology, 2004.
39. Thompson, J.F. and Bedient, P.B. "Urban Storm Water Design and Management" The Engineering Handbook, Chapter 94, CRC Press, 2004, 21 pp.

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40. Capiro, N.L. and Bedient P.B. "Transport of Reactive Solute in Soil and Groundwater" The Encyclopedia of Water, John Wiley and Sons, Inc., New York, NY, USA pp. 524-531, 2005.
41. Bedient, P.B., Holder, A., and Benavides, J. "Advanced Analysis of T.S. Allison's Impacts" submitted to Jn. of American Water Resources Assn., 2004.
42. Bedient, P. B., A. Holder, J. Benavides, and B. Vieux "Radar-Based Flood Warning System applied to TS Allison, ASCE Journal of Hydrologic Engineering, 8(6), pp 308-318, Nov, 2003.
43. Glenn, S., Bedient, P.B., and B. Vieux "Ground Water Recharge Analysis Using NEXRAD in a GIS Framework" submitted to Ground Water, October 2002.
44. Bedient, P.B., Vieux, B.E., Vieux, J.E., Koehler, E.R., and H.L. Rietz "Mitigating Flood Impacts of Tropical Storm Allison" accepted by Bulletin of American Meteorological Society, 2002.
45. El-Beshry, M., Gierke, J.S., and P.B. Bedient "Practical Modeling of SVE Performance at a Jet-Fuel Spill Site" ASCE Journal of Environmental Engineering pp. 630-638, (127) 7, July 2001.
46. El-Beshry, M.Z., Gierke, J.S., and P.B. Bedient "Modeling the Performance of an SVE Field Test" in Chapter 7, Vadose Zone Science and Technology Solutions, Brian B. Looney and Ronald W. Falta Editors, Vol. II, pp. 1157-1169, (2000).
47. Rifai, H.S., Brock, S.M. Ensor, K.B., and P.B. Bedient "Determination of Low-Flow Characteristics for Texas Streams" ASCE Journal of Water Resources Planning and Management, (126)5, pp.310-319, September-October 2000.
48. Bedient, P.B., Hoblit, B.C., Gladwell, D.C., and B.E. Vieux "NEXRAD Radar for Flood Prediction in Houston" ASCE Journal of Hydrologic Engineering, 5(3), pp. 269-277, July 2000.
49. Hamed, M.M., Nelson, P.D., and P.B. Bedient "A Distributed Site Model for Non-equilibrium Dissolution of Multicomponent Residually Trapped NAPL" Environmental Modeling and Software, (15), pp. 443-450, September 2000.
50. Holder, A.W., Bedient, P.B., and C.N. Dawson "FLOTTRAN, a Three-dimensional Ground Water Model, with Comparisons to Analytical Solutions and Other Models" Advances in Water Resources, pp. 517-530. 2000.
51. Rifai, H.S., Bedient, P.B., and G.L. Shorr "Monitoring Hazardous Waste Sites: Characterization and Remediation Considerations" Journal of Environmental Monitoring, 2(3), pp. 199-212, June 2000.
52. Hoblit, B.C., Baxter, E.V., Holder, A.W., and P.B. Bedient "Predicting With Precision" ASCE Civil Engineering Magazine, 69(11), pp. 40-43, November 1999.
53. Bedient, P.B., Holder, A.W., Enfield, C.G., and A.L. Wood "Enhanced Remediation Demonstrations at Hill Air Force Base: Introduction" Innovative Subsurface Remediation: Field Testing of Physical, Chemical, and Characterization Technologies, Mark L. Brusseau, et al., eds., pp. 36-48, American Chemical Society, Washington, DC, 1999.
54. Holder, A.W., Bedient, P.B., and J.B. Hughes "Modeling the Impact of Oxygen Reaeration on Natural Attenuation" Bioremediation Journal, 3(2): 137-149, June 1999.
55. Characklis, G.W., Griffin, R.C., and P.B. Bedient "Improving the Ability of a Water Market to Efficiently Manage Drought" Water Resources Research, (35) 3, 823-831, March 1999.

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56. Vieux, B.E. and P.B. Bedient "Estimation of Rainfall for Flood Prediction from WSR-88D Reflectivity: A Case Study, 17-18 October 1994" Weather and Forecasting, 1998 American Meteorological Society, 13:2, 407-415, June 1998.
57. Bedient, P.B. "Hydrology and Transport Processes" Subsurface Restoration, C.H. Ward, J.A. Cherry and M.R. Sclaf, editors, Ann Arbor Press, Chelsea, MI, 59-73, 1997.
58. Hamed, M.M. and P.B. Bedient "On the Performance of Computational Methods for the Assessment of Risk from Ground-Water Contamination" Ground Water, 35(4), 638-646, July-August 1997.
59. Hamed, M.M. and P.B. Bedient "On the Effect of Probability Distributions of Input Variables in Public Health Risk Assessment" Risk Analysis, 17(1), 97-105, 1997.
60. Hamed, M.M., Bedient, P.B., and J.P. Conte "Numerical Stochastic Analysis of Groundwater Contaminant Transport and Plume Containment" Journal of Contaminant Hydrology, 1996, 24 pp.
61. Hamed, M.M., Bedient, P.B., and C.N. Dawson "Probabilistic Modeling of Aquifer Heterogeneity Using Reliability Methods" Advances in Water Resources, 19(5), 277-295, 1996.
62. Sweed, H., Bedient, P.B., and S.R. Hutchins "Surface Application System for In-Situ Bioremediation: Site Characterization and Modeling" Groundwater Journal, 34(2), 211-222, 1996.
63. Hamed, M.M., Conte, J.P., and P.B. Bedient "Uncertainty Analysis of Subsurface Transport of Reactive Solute Using Reliability Methods" Groundwater Models for Resources Analysis and Management, CRC Press, Inc., Chapter 8:123-135 1995.
64. Hamed, M.M., Conte, J.P., and P.B. Bedient "Probabilistic Screening Tool for Groundwater Contamination Assessment" ASCE Journal of Environmental Engineering, 121(11): 767-775, (1995).
65. Rifai, H.S. and P.B. Bedient "A Review of Biodegradation Models: Theory and Applications" Groundwater Models for Resources Analysis and Management, CRC Press, Inc., Chapter 16:295-312 (1995).
65. Rifai, H. S., Newell, C. J., Bedient, P.B., Shipley, F.S., and R.W. McFarlane, The State of the Bay, The Galveston Bay National Estuary Program, Webster, TX, 232 pp. (1994).
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67. Bedient, P.B. and H.S. Rifai "Modeling in Situ Bioremediation" In Situ Bioremediation, When Does It Work?" National Academy Press, pp. 153-159 (1993).
68. Rifai, H. S., Bedient, P.B., Hendricks, L.A., and K. Kilborn "A Geographical Information System (GIS) User Interface for Delineating Wellhead Protection" Ground Water, 31:3, pp. 480-488 (1993).
69. H. S. Rifai, Newell, C. J., and P.B. Bedient "Getting to the Nonpoint Source with GIS" Civil Engineering, June, pp. 44-46 (1993).
70. H. S. Rifai, Newell, C. J., and P.B. Bedient "GIS Enhances Water Quality Modeling" GIS World, August, pp. 52-55 (1993).

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71. Bedient, P.B., Schwartz, F.W., and H.S. Rifai "Hydrologic Design for Groundwater Pollution Control" Handbook of Hydrology, McGraw Hill, pp. 29.1-29.47 (1993).
72. Wise, W.R., Robinson, G.C., and P.B. Bedient "Chromatographic Evidence for Nonlinear Partitioning of Aromatic Compounds Between Petroleum and Water" Ground Water, 30(6): 936-944. (Nov. - Dec. 1992).
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C. Conference Proceedings and Other Technical Publications (since 1995):

1. Panakka, P., Juan, A., Garcia, M., Padgett, J. E., & Bedient, P. (2019). Towards enhanced response: Integration of a flood alert system with road infrastructure performance models. Paper presented at the Structures Congress 2019: Buildings and Natural Disasters - Selected Papers from the Structures Congress 2019, 294-305. doi:10.1061/9780784482223.029

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5. Deitz, R., Christian, J. K., Wright, G., Fang, Z., and Bedient, P. B. (2012). "Linkage of Rainfall-Runoff and Hurricane Storm Surge in Galveston Bay", American Geophysical Union (AGU) 2012 Fall Meeting, San Francisco, CA, December 3-7.
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14. Christian, J. K., Fang, Z., and Bedient, P. B. (2011). "Probabilistic Floodplain Delineation", 2011 World Environmental and Water Resources Congress, Palm Springs, California. May 22-26
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37. Bedient, P.B., "Foresight Panel on Environmental Effects" Houston-Galveston Area Council, Houston, Texas, February 5, 2008
38. Bedient, P.B., Fang, Z., Hovinga, R. M., "Flood Warning System (FAS2) Rice University Training, Houston, Texas, January 15, 2008
39. Bedient, P.B., Fang, Z., Hovinga, R. M., SSPEED Meeting, Houston, Texas, November 16, 2007
40. Fang, Z. and Bedient, P.B. "Real-time Hydraulic Prediction Tool – Floodplain Map Library (FPML)". American Water Resources Association 2007 Annual Conference, Albuquerque, New Mexico, November 12-15, 2007.

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42. Fang, Z. and Bedient, P.B. "The Future of Flood Prediction in Coastal Areas" Severe Storm Prediction, Evacuation, and Education from Disasters Conference, Rice University, Houston Texas, May 8-10, 2007
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46. Bedient, P.B., Fang, Z., and R. Hovinga "Prediction for Severe Storm Flood Levels for Houston Using Hurricane Induced Storm Surge Models in GIS Frame" Proceedings of AWRA GIS Conference, Houston, TX, May 8-10, 2006.
47. Fang, Z., Safiolea, E., and P.B. Bedient "Enhanced Flood Alert and Control Systems for Houston" Proceedings of 25th American Institute of Hydrology Conference, Baton Rouge, LA, May 21-24, 2006.
48. Gordon, R. and P.B. Bedient "Rice University Engineers Without Borders: An Exercise in International Service Learning" Proceedings of the ASE Education Conference, Chicago, June 18-21, 2006.
49. Gordon, R., Benavides, J.A., Hovinga, R., Whitko, A.N., and P.B. Bedient "Urban Floodplain Mapping and Flood Damage Reduction Using LIDAR, NEXRAD, and GIS" Proceedings of the 2006 AWRA Spring Specialty Conference: GIS and Water Resources IV, Houston, TX, May 8-10, 2006.
50. Fang, Z. and P.B. Bedient "IP2 Houston Flood Alert and Response-2006" CASA Meeting, Estes Park, Co, October 16-17, 2006.
51. Safiolea, E., Bedient, P.B., and B.E. Vieux "Assessment of the Relative Hydrologic Effects of Land Use Change and Subsidence Using Distributed Modeling" (July 2005).
52. Holder, A.W., Hoblit, B., Bedient, P.B., and B.E. Vieux "Urban Hydrologic Forecasting Application Using the NEXRAD Radar in Houston" Proceedings of the Texas Section American Society of Civil Engineers, Austin, TX, pp. 279-288, April 5-8, 2000.
53. Benavides, J.A., Pietruszewski, B., Stewart, E., and P.B. Bedient "A Sustainable Development Approach for the Clear Creek Watershed" Proceedings of the Texas Section American Society of Civil Engineers, Austin, TX, pp. 269-278, April 5-8, 2000.
54. Bedient, P.B., Rifai, H.S., and C.W. Newell "Decision Support System for Evaluating Pump-and-Treat Remediation Alternatives" Pollution Modeling: Vol. 1, Proceedings for Envirosoft 94, November 16-18, 1994, San Francisco, CA, Edited by P. Zannetti, Computational Mechanics Publications, Wessex Inst of Technology, Southampton, UK.

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56. Hamed, M.M., Holder, A.W., and P.B. Bedient "Evaluation of Reaeration Using a 3-D Groundwater Transport Model" Proceedings of the In Situ and On-Site Bioremediation Symposium, New Orleans, LA, 1997, 1:75-80.
57. Holder, A.W., Bedient, P.B., and J.B. Hughes "TCE and 1,2-DCE Biotransformation Inside a Biologically Active Zone" Proceedings of the First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 18-21, 1:219-224, 1998.
58. Hamed M.M. and P.B. Bedient "Uncertainty Analysis of Natural Attenuation in Groundwater Systems" Proceedings of the In Situ and On-Site Bioremediation Symposium, New Orleans, LA, 1997, 1:43-48.
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60. Hamed, M.M., Bedient, P.B., and J.P. Conte "Probabilistic Modeling of Contaminant Transport in the Subsurface" Proceedings of the International Association of Hydro geologists Conference Solutions '95", Edmonton, Canada, June 4-10, 1995.

D. Invited Lectures (Recent since 2000):

1. The Resilience and Adaptation to Climate Risks Workshop: NASA Johnson Space Center and the Houston/Galveston Area, March 8, 2012, Houston, Texas
2. Bedient, P.B., SSPEED Conference. Chair and Organizer, "*Hurricane Ike, Revisited*," September 14, 2009, Houston, Texas.
3. Bedient, P.B., SSPEED Conference. Chair and Organizer, "*Severe Storm Prediction and Global Climate Impact in the Gulf Coast*," Sponsored by American Institute of Hydrology. October 29-31, 2008, Houston, Texas. (Attended by over 150 guests and speakers).
4. Bedient, P.B., SSPEED Conference. Chair and Organizer, "*Severe Storm Prediction and Global Climate Impact in the Gulf Coast*," Sponsored by American Institute of Hydrology. October 29-31, 2008, Houston, Texas. (Attended by over 150 guests and speakers).
5. Bedient, P.B., Robinson, and H., Fang, Z. (2008). "Distributed Hydrologic Model Development in the Topographically Challenging Yuna River Watershed, Dominican Republic". Meeting in Dominican Republic before the President October 20, 2008.
6. Bedient, P.B. (June, 2008) Plan for the Dominican Republic Flood Study, before the Ministers of Education, Environment, and Economic Development.
7. Bedient, P.B. "Advanced Flood Alert Systems in Texas" International Disaster Response Conference, Daves, Switzerland, August 28, 2006.
8. Bedient, P.B. "IP2 Flood Alert System for Houston" CASA Meeting NSF Review, UMASS. April, 2006.
9. Bedient, P.B. "Severe Storm Impacts in the Gulf Coast" Severe Storm Impacts and Disaster Response in Gulf Coast, Houston, Rice University, March 15-16, 2006.

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10. Bedient, P.B. "Living with Severe Storms in the Gulf Coast- Scientia Lecture" Rice University, Houston, TX. (September 2005).
11. Bedient, P.B., Fang, Z., Safiolea, E., and B.E. Vieux "Enhanced Flood Alert System for Houston" 2005 National Hydrologic Council Conference: Flood Warning Systems, Technologies and Preparedness, Sacramento, California. (May 16-20)
12. Fang, Z. and Bedient, P.B. "Enhanced Flood Alert and Control Systems for Houston" Proceedings of the 25th American Institute of Hydrology Conference: Challenges of Coastal Hydrology and Water Quality. Baton Rouge, Louisiana, May 21-24, 2006.
13. Fang, Z., Bedient, P.B., and R. Hovinga "Prediction of Severe Storm Flood Levels for Houston Using Hurricane Induced Storm Surge Models in a GIS Frame" Proceedings of AWRA 2006 Spring Specialty Conference: GIS and Water Resources IV. Houston, Texas, May 8-10, 2006.
14. Bedient, P.B. "Impacts of Climate Change on Transportation Systems and Infrastructure" Gulf Coast Study, Lafayette, LA. (May 2005)
15. Capiro, N.L., Da Silva, M.L.B., Stafford, B.P., Alvarez, P.J.J., and P.B. Bedient "Changes in Microbial Diversity Resulting from a Fuel-Grade Ethanol Spill" Eighth International Symposium on In Situ and On-Site Bioremediation, Baltimore, MD. (June 2005).
16. Safiolea, E. and P. B. Bedient "Assessment of the Relative Hydrologic Effect of Land Use Change and Subsidence Using Distributed Modeling" EWRI Watershed Management Conference, Williamsburg, VA. (July 9-22, 2005)
17. Capiro, N.L., Stafford, B., He, X., Rixey, W.G., and P.B. Bedient "A Large-Scale Experimental Investigation of Ethanol Impacts on Groundwater Contamination" Presentation at the Fourth International Conference on Remediation of Chlorinated and Recalcitrant Compounds; Monterey, CA; May 2004.
18. Capiro, N.L., Da Silva, M.L.B., Stafford, B.P., Alvarez, P.J.J., and P.B. Bedient "Changes in Microbial Diversity Resulting from a Fuel-Grade Ethanol Spill" Accepted for Presentation at The Eighth International Symposium on In Situ and On-Site Bioremediation; Baltimore, MD. June 2005.
19. Safiolea, E. and P.B. Bedient "Analysis of Altered Drainage Patterns and Subsidence Impact Using a Distributed Hydrologic Model" AWRA Annual Water Resources Conference in Orlando FL, November 2004.
20. Safiolea, E. and Philip B. Bedient "Assessment of the Relative Hydrologic Effect of Land Use Change and Subsidence using Distributed Modeling" EWRI Watershed Management Conference in Williamsburg VA, Jul19-22, 2005.
21. Bedient, P.B. and J.A. Benavides "Use of QPE and QPF for Flood Alert (FAS2) in the Houston, TX Test Bed" CASA NSF ERC Conference, "Estes Park, CO, October, 2004.
22. Capiro, N.L., Adamson, D.T., McDade, J.M., Hughes, J.B., and P.B. Bedient "Spatial Variability of Dechlorination Activity Within a PCE DNAPL Source Zone" Presentation The 7th International Symposium In Situ and On-Site Bioremediation; Orlando, FL; June 2003
23. Benavides, J.A. and P.B. Bedient "Improving the Lead-Time and Accuracy of a Flood Alert System in an Urban Watershed" 2003 AWRA Annual Conference, San Diego, California, November 2003.

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24. Whitko, A.N. Bedient, P.B., and S. Johnson "Sustainable Flood Control Strategies in the Woodlands – Thirty Years Later" 2003 AWRA Annual Conference, San Diego, California, November 2003.
25. Safiolea E., Hovinga, R., and P.B. Bedient " Impact of Development Patterns on Flooding in Northwest Houston using LIDAR Data" 2003 AWRA Annual Conference, San Diego, California, November 2003
26. Benavides, J.A. and P.B. Bedient "Improving the Performance of a Flood Alert System Designed for a Rapidly Responding Urban Watershed" 2003 Conference on Flood Warning Systems Technologies and Preparedness, Dallas, Texas. October 2003.
27. Bedient, P.B., Holder, A., and Baxter Vieux "A Radar-Based Flood Alert System (FAS) Designed for Houston, TX" *International Conference on Urban Storm Drainage*, Portland, OR, September 2002.
28. Holder, A., Stewart, E., and P.B. Bedient "Modeling an Urban Drainage System with Large Tailwater Effects under Extreme Rainfall Conditions" *International Conference on Urban Storm Drainage*, Portland, OR, September 2002.
29. Glenn, S., Bedient, P.B., and B. Vieux "Analysis of Recharge in Ground Water Using NEXRAD in a GIS Format" *AWRA Summer Specialty Conference*, Keystone, CO, July, 2002.
30. Bedient, P.B. "Flood ALERT System (FAS) for Brays Bayou and the TMC" T.S. Allison: A Brays Bayou Event, Rice University Conference Presentation, and November 13, 2001.
31. Bedient, P.B. "Flood ALERT System for the Texas Medical Center" Hurricanes and Industry, Houston Conference Presentation, November 7, 2001.
32. Bedient, P.B. and J.A. Benavides "Analyzing Flood Control Alternatives for the Clear Creek Watershed in a Geographic Information Systems Framework" presented at ASCE's EWRI Spring 2001 World Water & Environmental Resources Congress Conference.
33. Hoblit, B.C., Bedient, P.B., B.E. Vieux, and A. Holder "Urban Hydrologic Forecasting: Application Issues Using WSR-88D Radar" *Proceedings American Society of Civil Engineers Water Research, Planning and Management 2000 Conference*, Minneapolis, MN, August 2000.

Exhibit 2

**2009 MASTER PLAN
ADDICKS AND BARKER RESERVOIRS
BUFFALO BAYOU AND TRIBUTARIES
FORT BEND AND HARRIS COUNTIES, TEXAS**



**U.S. ARMY CORPS OF ENGINEERS, GALVESTON DISTRICT
GALVESTON, TEXAS
AUGUST 2009**

US Army Corps of Engineers
Galveston District

Master Plan
Addicks and Barker Reservoirs

The reservoirs were built to protect downtown Houston from flooding. Harris County has been subjected to at least 14 major storm events since 1853 (USGS 2003). The following is a list of major storms impacting the Buffalo Bayou watershed and their associated damages:

1929 – Major flooding resulted from a Gulf storm causing 14 hours of rain and at least 10 inches of rainfall throughout the county resulting in seven deaths and over one million dollars in damages. All bayous were over their banks.

1935 - Major flooding following 16.5 inches of rainfall caused eight deaths and over \$2.5 million in property damages.

1973 - A catastrophic storm produced 15 inches of rain and caused an estimated \$50 million in damages.

1979 – Tropical Storm Claudette produced the highest recorded rainfall event recorded in U.S history in a 24-hour period, dropping 43 inches of rain on Alvin, Texas, located 50 miles southeast of the reservoirs. If this event had occurred over the Addicks and Barker watersheds, their reservoir capacities may have been exceeded.

1981 - A tropical depression caused about two to 10 inches of rain to fall in the Houston area.

1983 – Hurricane Alicia dropped 15 inches of rain in eastern Harris County over a four-day period. The death toll from Alicia was 11, with nearly \$500 million in damages. Due to its passage through Galveston and not Freeport, the impacts to Addicks and Barker Reservoirs were less pronounced.

1992 – A rain event caused the flooding of I-10 and one death. The upper Buffalo Bayou watershed accumulated nine inches of rain in six hours. This event, along with considerable rainfall over the previous three months resulted in record pools levels at both Addicks and Barker Reservoirs.

1994 – As a result of the combination of residual atmospheric moisture from Hurricane Rosa and low-level moisture from the Gulf of Mexico, heavy rainfall caused severe flooding over a 38-county area including Harris and Fort Bend Counties. This event caused 22 flood-related deaths and damaged 15,775 homes. FEMA declared 29 of the 28 counties to be disaster areas and approved \$54 million in disaster assistance.

1998 – In September, Tropical Storm Frances produced over 10 inches of rain that fell on Harris County. The total damage caused by Frances to Harris, Galveston, Brazoria, and Matagorda Counties totaled \$286 million. Two months later, in November, another heavy rain event produced about eight inches of rain over the Houston area.

2001 - Tropical Storm Allison hit the southeastern coast of Texas in early June and dropped almost 36 inches of rain over a five-day period resulting in 22 deaths and \$5 billion in damages. The center of this event was 50 miles northeast of the Addicks and

US Army Corps of Engineers
Galveston District

Master Plan
Addicks and Barker Reservoirs

Barker watershed and could have potentially exceeded reservoir capacity had the storm event occurred directly over the reservoirs.

2002 – In late October strong thunderstorms caused five to eight inches of rain to fall in a short time in areas west and north of Houston.

2005 - Hurricane Rita caused \$159.5 million in property and crop damage in southeastern Texas in September. In Harris County, sustained wind gusts of 60 mph caused widespread power outages.

Table B-1. Top-Ten Recorded Flood Pools* with Reference Pools - Addicks Reservoir

| Event | Elevation ¹ | Surface Area (Acres) | Capacity in Acre-feet ² | % Capacity Max. Pool ³ | % Capacity GOL ⁴ |
|--------------------------|------------------------|----------------------|------------------------------------|-----------------------------------|-----------------------------|
| Max. Pool ⁵ | 108.00 | 16,199 | 199,643 | 100.0 | 100.0 |
| GOL ⁶ | 103.20 | 13,108 | 130,203 | 65.0 | 100.0 |
| 100yr Flood ⁷ | 100.5 | 11,534 | 96,793 | 48.0 | 74.0 |
| March 6 1992 | 97.64 | 9,321 | 66,930 | 33.5 | 51.6 |
| April 30, 2009 | 97.08 | 8,913 | 61,825 | 31.0 | 47.7 |
| November 7, 2002 | 96.63 | 8,544 | 57,896 | 29.0 | 44.6 |
| St Hwy 6 (edge) | 96.16 | 8,157 | 53,971 | 27.0 | 41.6 |
| November 17, 1998 | 95.88 | 7,939 | 51,719 | 25.9 | 39.9 |
| October 23, 1994 | 95.81 | 7,888 | 51,165 | 25.6 | 39.5 |
| May 15, 1968 | 95.34 ⁸ | *** | *** | *** | *** |
| November 25, 2004 | 95.06 | 7,354 | 45,450 | 22.8 | 35.0 |
| July 8, 2007 | 95.00 | 7,312 | 45,010 | 22.5 | 34.7 |
| September 4, 1981 | 94.43 | 6,979 | 40,937 | 20.5 | 31.6 |
| September 17, 1998 | 94.13 | 6,807 | 38,869 | 19.5 | 30.0 |
| Conduit invert | 67.50 | 7 | 35 | 0 | 0 |

*As of July 2009

1. Elevation of water surface is in feet-NAVD, Epoch 2001.

2. One acre-foot of water is one acre of water, one foot deep.

3. Percent of capacity of maximum possible pool before water spills around end of dam.

4. Percent of capacity of maximum possible pool contained within the government owned land (GOL).

5. Maximum possible pool before water spills around the end of the dam.

6. Maximum possible pool contained within the government owned land.

7. Pool that would result from a 100 year storm event over the entire watershed.

8. Original elevations of 100.03 ft M.S.L. adjusted to reflect NAVD 1988.

Despite numerous major flood events in the Metropolitan Houston area since 1963 when the remaining two conduits at each dam were gated, Addicks and Barker Reservoirs have not exceeded the limits of government-owned land in any flood event (Tables B-1 and B-2). However, had some of these events been centered over Addicks and Barker Reservoirs or the Upper Buffalo Bayou Watershed, the combined rainfall and runoff

US Army Corps of Engineers
Galveston District

Master Plan
Addicks and Barker Reservoirs

could have resulted in flood pools exceeding the limits of government owned land and possibly exceeding the capacity of Addicks and Barker Dams.

Flood Risk Management. Addicks and Barker Reservoirs fulfill their mission by reducing the damage to property downstream of the dams caused by flooding. The USACE is responsible for estimating the value of the reservoirs, and one way to do so is by estimating the monetary amount of flood damage avoided by the presence and operation of the reservoirs. Table B-3 shows estimated flood damage prevented by operation of Addicks and Barker Reservoirs.

Table B-2. Top-Ten Recorded Flood Pools* with Reference Pools - Barker Reservoir

| Event | Elevation ¹ | Surface Area (Acres) | Capacity in Acre-feet ² | % Capacity Max. Pool ³ | % Capacity GOL ⁴ |
|--------------------------|------------------------|----------------------|------------------------------------|-----------------------------------|-----------------------------|
| Max. Pool ⁵ | 104.00 | 16,543 | 209,600 | 100.0 | 100.0 |
| GOL ⁶ | 95.00 | 12,036 | 82,921 | 40.0 | 100.0 |
| 100yr Flood ⁷ | 95.50 | 12,149 | 88,962 | 42.0 | 100.0 |
| March 6, 1992 | 93.60 | 11,491 | 66,489 | 31.7 | 80.2 |
| November 7, 2002 | 93.24 | 11,404 | 62,368 | 29.8 | 75.2 |
| W. Pkwy (edge) | 93.21 | 11,396 | 62,026 | 29.6 | 74.8 |
| November 18, 1998 | 92.31 | 10,987 | 57,934 | 27.6 | 69.9 |
| July 9, 2007 | 91.85 | 10,736 | 46,935 | 22.4 | 56.6 |
| November 28, 2004 | 91.69 | 10,699 | 45,225 | 21.6 | 54.5 |
| April 20, 1991 | 91.34 | 10,425 | 41,539 | 19.8 | 50.1 |
| May 1, 2009 | 91.21 | 10,347 | 40,189 | 19.2 | 48.5 |
| May 15, 1968 | 90.60 ⁸ | *** | *** | *** | *** |
| May 31, 1997 | 90.58 | 9,495 | 33,890 | 16.2 | 40.9 |
| October 22, 1994 | 90.54 | 9,427 | 33,512 | 16.0 | 40.4 |
| Conduit invert | 70.2 | 0 | 0 | 0 | 0 |

*As of July 2009

1. Elevation of water surface is in feet-NAVD 1988, 2001.
2. One acre-foot of water is one acre of water, one foot deep.
3. Percent of capacity of maximum possible pool before water spills around end of dam.
4. Percent of capacity of maximum possible pool contained within the government owned land (GOL).
5. Maximum possible pool before water spills around the end of the dam.
6. Maximum possible pool contained within the government owned land.
7. Pool that would result from a 100 year storm event over the entire watershed.
8. Original elevations of 94.60 MSL adjusted to reflect NAVD 1988.

Exhibit 3



U.S. Army Corps
of Engineers
Galveston District

**ADDICKS AND BARKER RESERVOIRS
BUFFALO BAYOU AND TRIBUTARIES
SAN JACINTO RIVER BASIN, TX**

WATER CONTROL MANUAL

NOVEMBER 2012

USACE016290

II - DESCRIPTION OF PROJECT

2-01. Location. The Buffalo Bayou watershed is within the San Jacinto River Basin, and lies primarily in Harris and Fort Bend Counties in southeast Texas. Barker Dam is located on Buffalo Bayou, and Addicks Dam is located on South Mayde Creek, a tributary of Buffalo Bayou. Both dams are located on the northwestern boundaries of the city limits of Houston, Texas. The top of dam at the outlet works of Addicks Reservoir are located at approximate latitude 29.790614° and longitude -95.623792°. The top of dam at the outlet of Barker Reservoir is located at approximate latitude 29.769717° and longitude -95.646587°. An overall vicinity map is shown on Plate 2-01.

2-02. Purpose. Addicks and Barker Reservoirs contribute to the overall purposes of authorized Buffalo Bayou flood risk management projects, which include the flood risk management protection provided to the City of Houston from flood damages, and prevention of excessive velocities and silt deposits in the Houston Ship Channel Turning Basin. The two reservoirs provide floodwater detention for flood risk management on the Buffalo Bayou watershed, and except during periods of rainfall, do not normally impound significant water.

2-03. Physical Components. Addicks and Barker Reservoirs are similar structures, consisting of long earthen embankments, with each dam having five conduits discharging flood waters into downstream channels. Subsidence has occurred along the dams and at the outlet works since construction to varying degrees. All elevations unless otherwise noted are NAVD 1988. The following paragraphs describe the physical components of the reservoir projects:

- a. Addicks Dam. The reservoir is formed by an earthen dam about 61,000 feet long constructed with 1 on 3 side slopes with a maximum height above stream bed of 48.5 feet. Both slopes are sodded and a 12-foot wide, hard surfaced road extends along the crest of the dam. The top of the dam is 121.0 feet, and the ends of the embankment terminate at a ground elevation of 108 feet on the north end and 112 feet on the west end. The spillway consists of the conduit outlet works in the South Mayde Creek channel section with emergency spillway around and over the ends of the dam. Plate 2-02 shows a local vicinity map for Addicks Reservoir. Plate 2-04 shows typical sections for Addicks Dam.
- b. Addicks Outlet Works. Five rectangular conduits, 8' wide x 6' high x 252' long, each with invert elevation 67.5 feet at intake, extend through the dam at the channel section. The four outside conduits are controlled by means of rectangular electrically-operated 8' x 10' sluice gates. The center conduit is controlled by twin 3' x 8' electrically-operated sluice gates. Discharge through the conduits passes through a 43.5 foot spillway into a 40' x 60' longitudinal stilling basin, then through a 150'

VII. WATER CONTROL PLAN

7-01. General Objectives. Construction of Addicks and Barker Reservoirs (a portion of the Buffalo Bayou, Texas project) was authorized by the River and Harbor Act, approved 20 June 1938, and modified by the Flood Control Acts of 11 August 1939, and 3 September 1954, for flood control on Buffalo Bayou for the protection of the City of Houston, Texas.

The Flood Control Act of 1944 provided authority to lease land in Addicks and Barker Reservoirs. Harris County leased 7,468 acres and developed Bear Creek Park for recreational purposes.

P.L. 89-72, Federal Water Project Recreation Act provides for Federal cost sharing in recreation development at completed projects. The City of Houston is planning development of the proposed 10,600 acre Cullen Park under this Act.

P.L. 92-500 requires that all Federal facilities shall be managed, operated and maintained so as to protect and enhance the quality of water and land resources through conformance with applicable Federal, state, interstate and local substantive standards.

7-02. Constraints. Constraints on the operation of Addicks and Barker Reservoirs are many and varied.

a. Spillway Design Flood Impacts. Addicks and Barker Reservoirs were originally designed as detention reservoirs with one controlled and four uncontrolled outlet conduits and no over-flow auxiliary spillways at the ends of the dams. The original design was predicated on the basis that the available freeboard plus the capacity of the gated outlet would prevent the embankments from overtopping. Later modifications (1948 and 1963) combined with the abandonment of the original channel rectification and diversion plan produced a situation where the spillway design flood was within 0.5 feet of flow around the ends of Barker dam and produced flow around the ends of Addicks dam. A preliminary revision to the spillway design flood in 1967 and an approved revision in 1977 both produced flow over the embankments of both dams. The occurrence of this situation could create a condition favorable for considerable property damage to the public and the possible loss of life. Spillway Design Flood Impacts are currently being reanalyzed as part of a Dam Safety Modification Study and this manual will be updated with results from the study after it is reviewed and approved.

b. Upstream Reservoir Impacts. Acquisition of real estate was based on the original design. Presently, pool levels in excess of Government-owned land will damage residential developments adjacent to Government-owned lands

c. Reservoir Release Restrictions. The original design included a downstream rectified channel and diversion channel with a capacity of approximately 18,000 cfs. Present non-damaging channel capacity is approximately 3,000 cfs. Releases, when combined with uncontrolled runoff and outflow from Addicks and Barker Reservoirs, are limited to 2,000 cfs. due to serious embankment problems and impacts to privately owned land. Reservoir gates should only be opened uniformly (symmetrically) to maintain structural integrity of the outfalls.

7-03. Overall Plan For Water Control. Addicks and Barker Reservoirs will be operated to provide maximum downstream flood protection on South Mayde Creek and Buffalo Bayou. Normal system operation will attempt to maintain equal available storage capacity for each reservoir within the constraints relating to the safety of the structure.

7-04. Standing Instructions To Dam Tender. A summary of these instructions is also included in Exhibit B.

a. Normal Operation. The Acting Natural Resource Manager will act as Dam Tender when regulation is required. The duties of the Dam Tender are as follows:

- (1) The Dam Tender will execute all instructions issued by the Reservoir Regulation Section relating to reservoir operations.
- (2) The Dam Tender is to observe and be cognizant of all available hydrologic and meteorological data that is pertinent to the operation of the projects. This data when requested by the Reservoir Regulation Section will be reported by telephone, e-mail or radio.
- (3) The Dam Tender will dispatch personnel to the dam sites to keep the gates under surveillance whenever reservoir pool stages warrants.
- (4) If one inch of rainfall or more falls in 24 hours or less and is recorded at the dam or on the watershed below the dam or if flooding is predicted below the dams, the Dam Tender will contact Reservoir Control for instructions. If an unwarranted delay does ensue, the Dam Tender will proceed to the reservoirs, close the gates, and then contact Reservoir Control personnel.
- (5) When releases are being made, the Dam Tender will monitor downstream conditions. If flow approaches the limiting flow of 2000 cfs at the Piney Point gage, or if one-half inch of rainfall in 24 hours or less occurs downstream or if flooding is predicted below the dams, the Dam Tender will notify the Reservoir Control. If an unwarranted delay does ensue, the Dam Tender will proceed to the reservoirs, close the gates, and then contact Reservoir Control personnel.

(6) The conduit outlet and stilling basin must be visually monitored very closely during all releases and during all high tailwater events. If unusual conditions occur (such as riprap displacement, surging, or submerged outlet) notify Water Management and Dam Safety immediately.

(7) The Dam Tender will notify lessees of land in the reservoirs when advised by the Reservoir Control that flooding of their land is imminent to permit the removal of stock and equipment from pertinent areas.

b. Emergency Operations. Communication between the Dam Tender and the Reservoir Control will be by telephone (primary), cell phone, or by e-mail, with the District radio net serving as a backup system. Emergency operations are to be used if communications fail, the Dam Tender's instructions are as follows:

(1) The Dam Tender will attempt to restore communications as soon as possible.

(2) If 1 inch of rainfall or more occurs in 24 hours or less below the reservoirs and/or flooding is predicted or occurring downstream, the Dam Tender will close all gates on the reservoirs and keep them under surveillance until communications are restored, or an authorized representative of the District arrives, or the induced surcharge regulation schedule dictates releases.

(3) If flood control releases are in progress, flooding is not forecasted and rainfall below the reservoirs is less than one-half inch in 24 hours, then no change in operation will be made until communications are restored or the induced surcharge regulation schedule dictates releases.

(4) If flood control releases are in progress and rainfall below the reservoirs is more than one-half inch in 24 hours or less, or flooding is predicted, the Dam Tender will close all gates on the reservoirs unless the induced surcharge regulation schedules (see paragraph 7-05.b.) are controlling.

(5) If inflow and pool elevation conditions dictate the use of the induced surcharge regulation schedule and instructions from Reservoir Control are unavailable, releases will be made by the Dam Tender in accordance with the induced surcharge regulation schedules shown on plates 7-03 and 7-04. The gates should remain at the maximum opening attained from the induced surcharge regulation schedules until reservoir levels fall to elevation 101 feet NAVD 1988 in Addicks Reservoir and 94.9 feet NAVD 1988 in Barker Reservoir. Then, if the outflow from both reservoirs when combined with the uncontrolled runoff downstream is greater than channel capacity, adjust the gates until the total discharges do not exceed channel capacity and follow the normal operating procedures.

(6) The conduit outlet and stilling basin must be visually monitored very closely during all releases and during all high tailwater events. If unusual conditions occur (such as riprap displacement, surging, or submerged outlet) close all conduit gates immediately and continue efforts to re-establish communications with the district office.

7-05. Flood Control. In keeping with the primary objective of flood control for Addicks and Barker Reservoirs, the general plan for reservoir regulation will be to operate the reservoirs in a manner that will utilize to the maximum extent possible, the available storage to prevent the occurrence of damaging stages on Buffalo Bayou within the limits placed by the constraints on project operations.

a. Normal Flood Control Regulation. Reservoir Control has the responsibility for directing the regulation of Addicks and Barker Reservoirs. Normal conditions are defined to exist when the reservoir pools are not in the range of the induced surcharge schedule.

(1) If flooding on Buffalo Bayou is neither expected nor occurring, the reservoirs will operate with two gates set at one-foot openings to pass normal low flows. This setting will limit the discharge on each reservoir to approximately 100 - 250 cfs.

(2) The gates on both reservoirs will be closed when 1 inch of rainfall occurs over the watershed below the reservoirs in 24 hours or less, or when flooding is predicted downstream.

(3) Keep the gates closed and under surveillance as long as necessary to prevent flooding below the dams. Begin releases in accordance with the paragraph below or in accordance with the induced surcharge schedule if pool elevations exceed 101 feet NAVD 1988 in Addicks or 95.7 feet NAVD 1988 in Barker. Continue these operations until the flood control storage has been evacuated or, in the case of induced surcharge releases, until a peak pool elevation is attained. Initial releases shall be made through two conduit gates until additional discharge capacity is needed.

(4) If inflow and pool elevation conditions do not dictate use of the induced surcharge regulation schedule for the reservoirs and the downstream runoff has receded to non-damaging stages, then open gates gradually to release amounts which, when combined with uncontrolled runoff, will not exceed 2,000 cfs at Piney Point. In order to maintain equal available storage in both reservoirs releases based on available downstream channel capacity will be made at rates necessary to maintain a difference in reservoir storages of no more than 20 percent. If, during the release period, rains in excess of 0.5 inch within 24 hours fall over the watershed below the reservoirs or flooding is predicted, the gates will be closed until the above operations can be resumed.

(5) When the reservoirs are emptied, close gates to normal position of two conduit gates at an opening of 1.0 foot-(releasing 100-250 cfs).

b. Induced Surcharge Flood Control Regulation. At any time the reservoir pool equals or exceeds 101 feet NAVD 1988 in Addicks Reservoir and 95.7 feet NAVD 1988 in Barker Reservoir monitoring of pool elevation should immediately ensue to determine if inflow is causing pool elevation to continue to rise. If inflow and pool elevation conditions dictate, reservoir releases will be made in accordance with the induced surcharge regulation schedules shown on plates 7-03 and 7-04. The gates should remain at the maximum opening attained from the induced surcharges regulation schedules until reservoir levels fall to elevation 101 feet NAVD 1988 in Addicks and 94.9 NAVD 1988 feet in Barker. Then, if the outflow from both reservoirs when combined with the uncontrolled runoff downstream is greater than channel capacity, adjust the gates until the total discharges do not exceed channel capacity and follow the normal operating procedures.

The conduit and stilling basin must be visually monitored very closely during all high releases and during high tailwater events. If unusual conditions occur (such as riprap displacement, surging, or submerged outlet) notify Water Management and Dam Safety immediately.

c. Constraints Regarding Flood Control Operation. Constraints on flood control operation are the same constraints enumerated in paragraph 7-02.

7-06. Recreation. Addicks and Barker Reservoirs are detention reservoirs with a normally dry pool. The lack of permanent storage normally prohibits releases for canoe races and float trips down Buffalo Bayou. The normal dry state of the reservoir area has encouraged local interest in recreational development on the Government-owned land.

a. Land Usage. Harris County has leased 3,085 acres in Addicks Reservoir for Bear Creek Pioneer Park. This land use development includes camping areas, hiking trails, picnic areas, play ground areas, petting zoo, baseball fields, soccer fields, dog park, Precinct 3 Headquarters, County Extension Agent. A Farm and Ranch Club, a Community Center, sports fields and courts, and three 18-hole golf courses with a club house. Use of the pool above elevation 88.9 feet NAVD 1988 for flood control starts to restrict the use of these facilities and creates public relation problems. Harris County has leased 7,800 acres in Barker Reservoir for George Bush Park. This development includes hike and bike trails, picnic areas, play ground areas, baseball fields, soccer fields, model airplane airport, dog park and a shooting range. Use of the pool above elevation 89.2 feet NAVD 1988 for flood control starts to restrict the use of these facilities and creates public relation issues.

Tributaries, Addicks and Barker Reservoirs, Hydrology" dated August 1977. Spillway design flood inflow hydrographs were computed consistent with Standard 1 design criteria as outlined in EC 1110-2-163 "Spillway and Freeboard Requirements for dams", dated August 1975. In accordance with these criteria the adopted spillway design storm was of probable maximum severity.

The 1977 spillway design rainfall was determined in accordance with the method described in Hydrometeorological Report No. 51, dated September 1976, entitled "Probable Maximum Precipitation Estimates, United States East of the 105h Meridian". The average rainfall for the spillway design flood was computed as 44.6 inches in 72 hours, with a peak intensity of 11.3 inches. The watershed of Addicks and Barker Reservoirs, Cypress Creek, and Buffalo Bayou above Piney Point were modeled to reflect ultimate conditions using the generalized storm network computation capability of HEC-1. Basins and subbasins were delineated on topographic maps of the study area. Loss rates and unit hydrograph coefficients were based on gages in the Houston area. All stream flow routing was accomplished using the Modified Puls method. Unit hydrographs of storm runoff were computed for each basin using the Clark synthetic unit hydrograph procedure.

The 1977 flood hydrograph adopted for Addicks Reservoir was produced by the spillway design storm centered over Addicks Reservoir Watershed, and the flood hydrograph adopted for Barker Reservoir was produced by the spillway design storm centered over Barker Reservoir Watershed. These centerings were selected because they produce the largest inflow rates into the reservoirs. For Addicks Reservoir the peak inflow was calculated as 294,570 cfs, and the total inflow volume was calculated as 462,145 acre-feet (approximately one-third of the inflow volume is overflow from Cypress Creek). For Barker Reservoir the peak inflow was calculated as 255,779 cfs, and the total inflow volume was calculated as 279,072 acre-feet. For additional information on the calculation of the SDF reference the 1977 hydrology report. The adopted spillway design flood hydrographs for Addicks and Barker are shown on plates 8-01 and 8-02.

The spillway design flood is currently being reanalyzed and this manual will be updated when the updated analysis is completed and approved.

- b. Standard Project Flood (SPF). The original standard project floods were computed in 1940. As with the original Spillway Design Flood the original Standard Project Flood was calculated incorporating features that were never actually constructed. In the original design of Addicks Reservoir the peak inflow was estimated to be 41,000 cfs, and the total inflow volume was estimated to be 146,000 acre-feet. For Barker Reservoir the peak inflow was

| <u>RESERVOIRS</u> | | | |
|------------------------------|-----------------------------------|----------------------------|--------------------------------|
| ITEM | DESCRIPTION OR QUANTITY AND UNITS | | |
| Feature | Elevation (ft, NAVD) | Surface Area (acres) | Storage Capacity (ac-ft) |
| <u>ADDICKS RESERVOIR</u> | | | |
| Conduit Invert | 67.5 | 7 | 35 |
| Limits of Government Land | 103.0 | 13,016 | 127,591 |
| 100-Year Flood | 100.3 | 11,397 | 94,500 |
| Standard Project Flood | 107.6 | 15,886 | 193,956 |
| Natural Ground at End of Dam | 108.0 | 16,199 | 199,643 |
| Top of Dam | 121.0 | | - |
| <u>BARKER RESERVOIR</u> | | | |
| Conduit Invert | 70.2 | 0 | 0 |
| Limits of Government Land | 95.0 | 12,036 | 82,921 |
| 100-Year Flood | 97.0 | 12,577 | 107,489 |
| Standard Project Flood | 98.3 | 13,412 | 125,061 |
| Natural Ground at End of Dam | 104.0 | 16,543 | 209,600 |
| Top of Dam | 113.1 | | - |

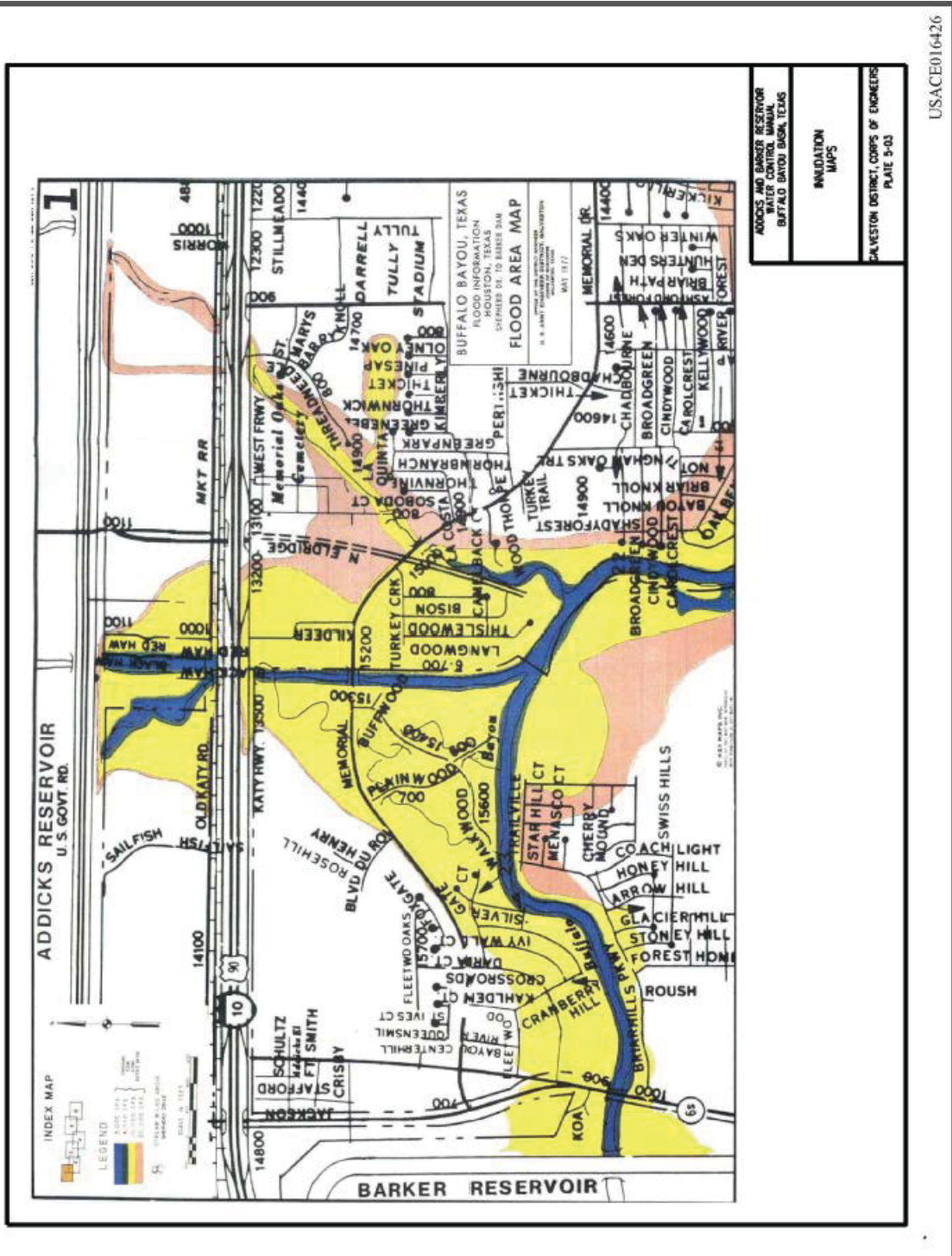
| | |
|----------------------------|---|
| Length of embankment | Addicks - 61,166 feet Barker - 71,900 feet |
| Initial real estate taking | Addicks - 12,460 acres Barker - 12,060 acres |
| Range of clearing | Not applicable |

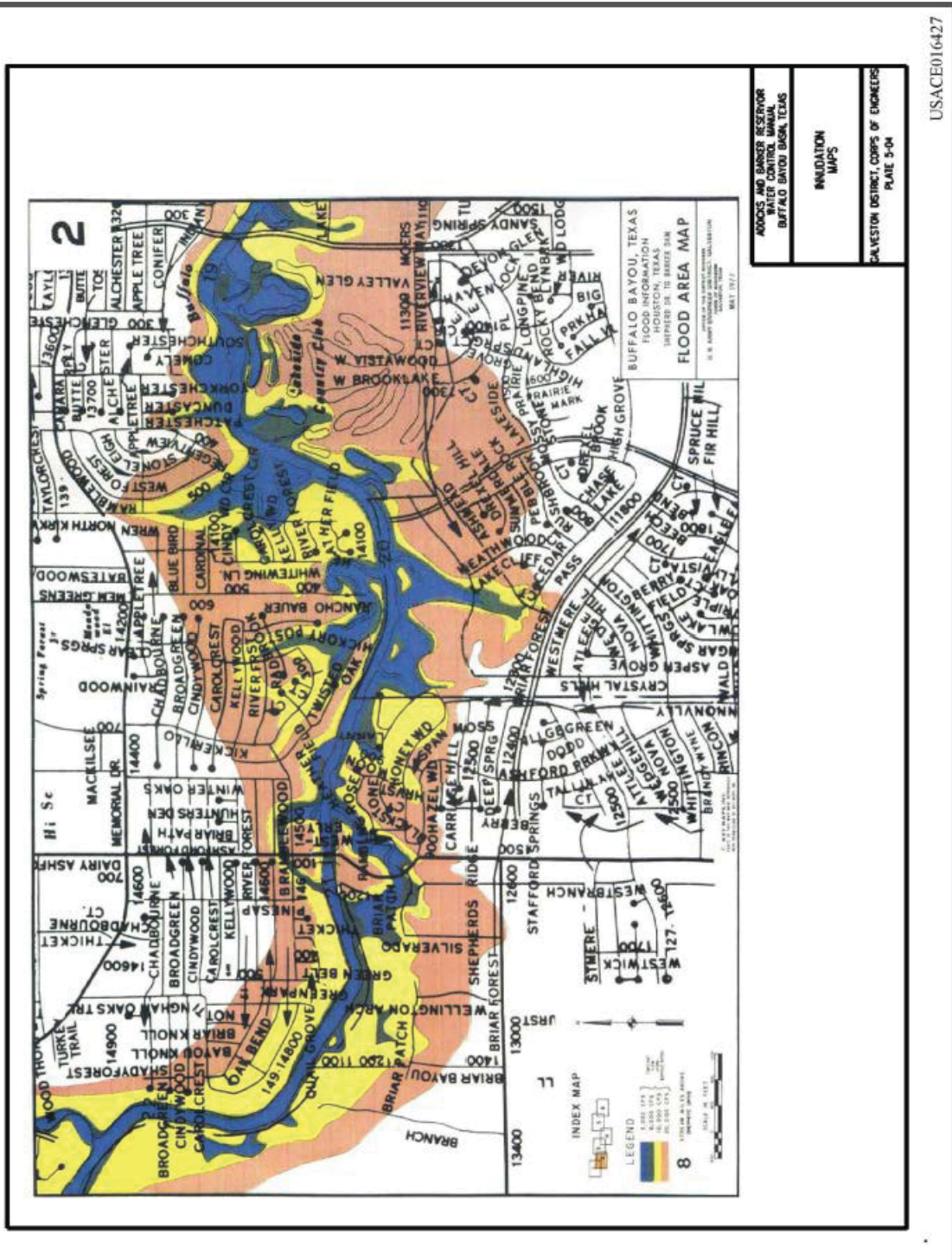
3. NORMAL OPERATION

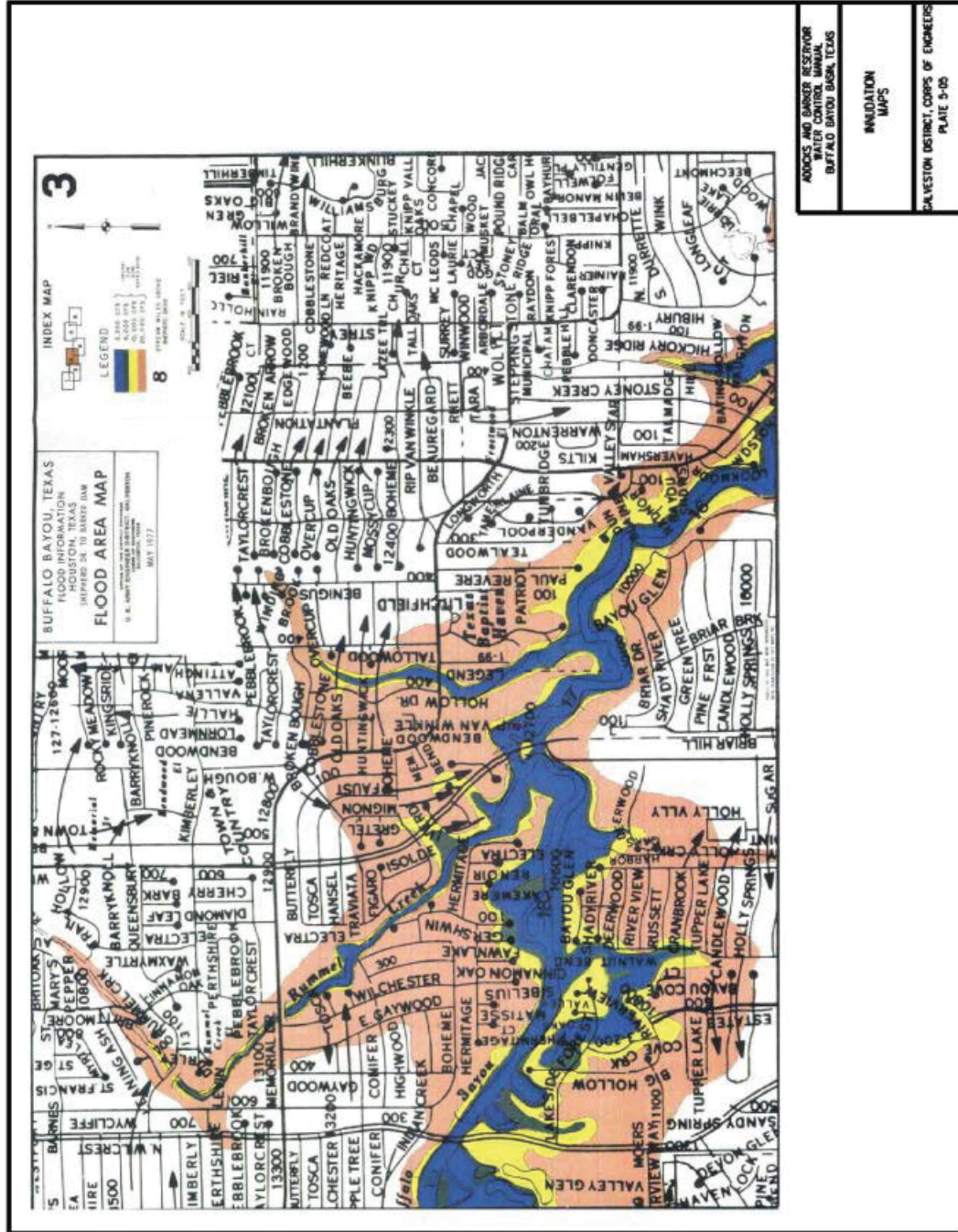
- a. Normal conditions - Set two conduit gates at an opening of 1.0 foot for passage of 100-250 cfs (normal flow at the dam).
- b. If 1 inch of rainfall, in 24 hours or less occurs, over the watershed below the reservoirs or when flooding is predicted downstream, the Hydrology and Hydraulics/Water Control (H&H/WC) Branch will be contacted. If an unwarranted delay will ensue, the Dam Tender will proceed to the reservoir, close the gates, and then contact the Hydrology and Hydraulics/Water Control (H&H/WC) Branch.
- c. When releases are being made and one-half inch of rainfall, in 24 hours or less, occurs over the watershed below the reservoirs or when flooding is predicted downstream, the Hydrology and Hydraulics/Water Control (H&H/WC) Branch will be contacted. If an unwarranted delay will ensue, the Dam Tender will proceed to the reservoirs, close the gates, and then contact the Hydrology and Hydraulics/Water Control (H&H/WC) Branch.

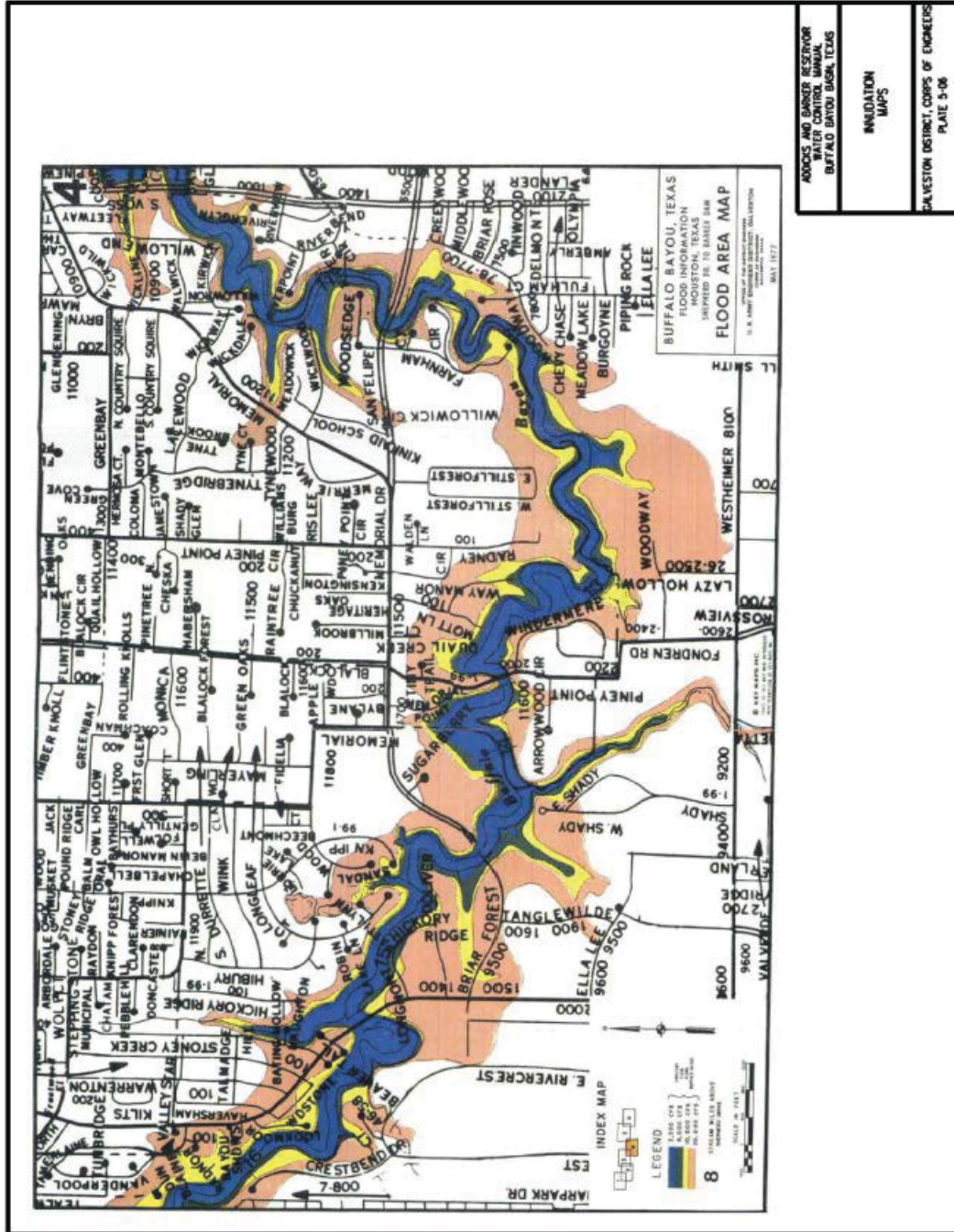
4. INDUCED SURCHARGE REGULATION

- a. Induced Surcharge conditions at Addicks and Barker Reservoirs are defined to exist at any time the reservoir pool equals or exceeds 101 feet NAVD 1988 at Addicks (about 45 percent of storage) and 95.7 feet NAVD 1988 at Barker (about 40 percent of storage) on the reservoir gages. If inflow and pool elevation conditions dictate the use of the induced surcharge regulation schedule, the Hydrology and Hydraulics/Water Control (H&H/WC) Branch will be contacted and instructions will be provided. Advance information will be given the public by the District Engineer or in his absence by the Officer-in-Charge through the media of the U.S. National Weather Service, other agencies, telephone, radio, television and newspapers.
- b. Emergency Conditions (Loss or Communications). If the Hydrology and Hydraulics/Water Control (H&H/WC) Branch cannot be contacted and communications are lost emergency conditions exist. Releases will be made independently by the Dam Tender in accordance with the induced surcharge regulation schedules shown on plates 7-03 and 7-04. Inflow and pool elevation conditions dictate the use of the induced surcharge regulation schedule in either reservoir, they will be made regardless of channel capacity downstream. Every effort should be made to provide advance

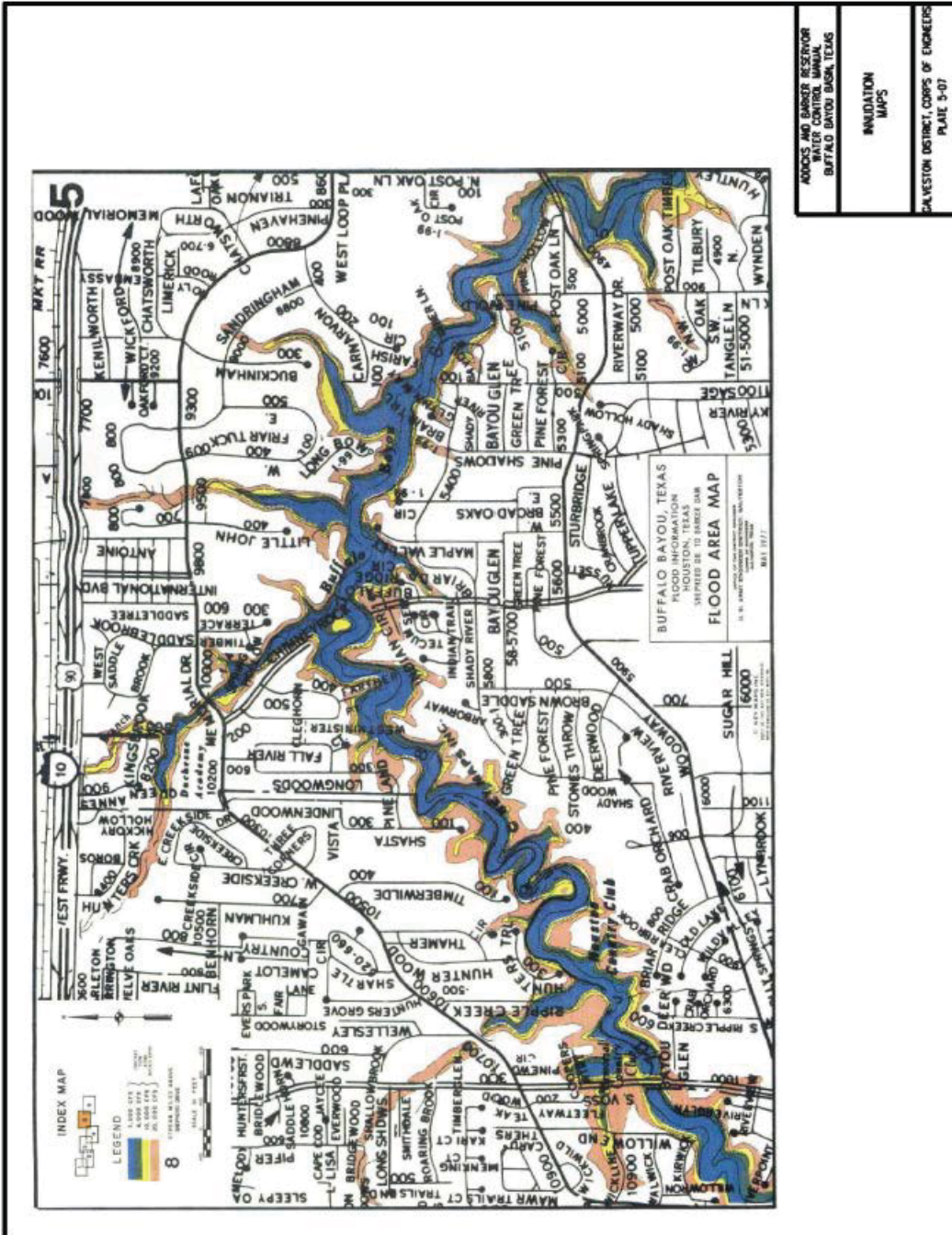




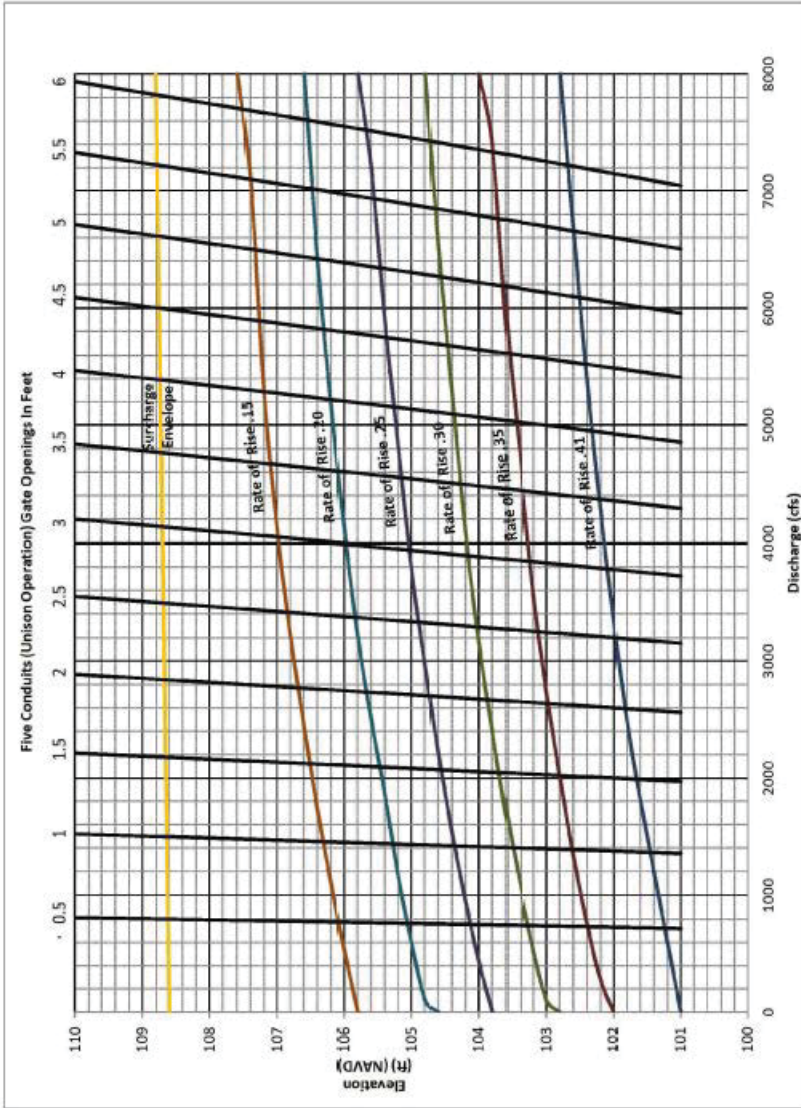




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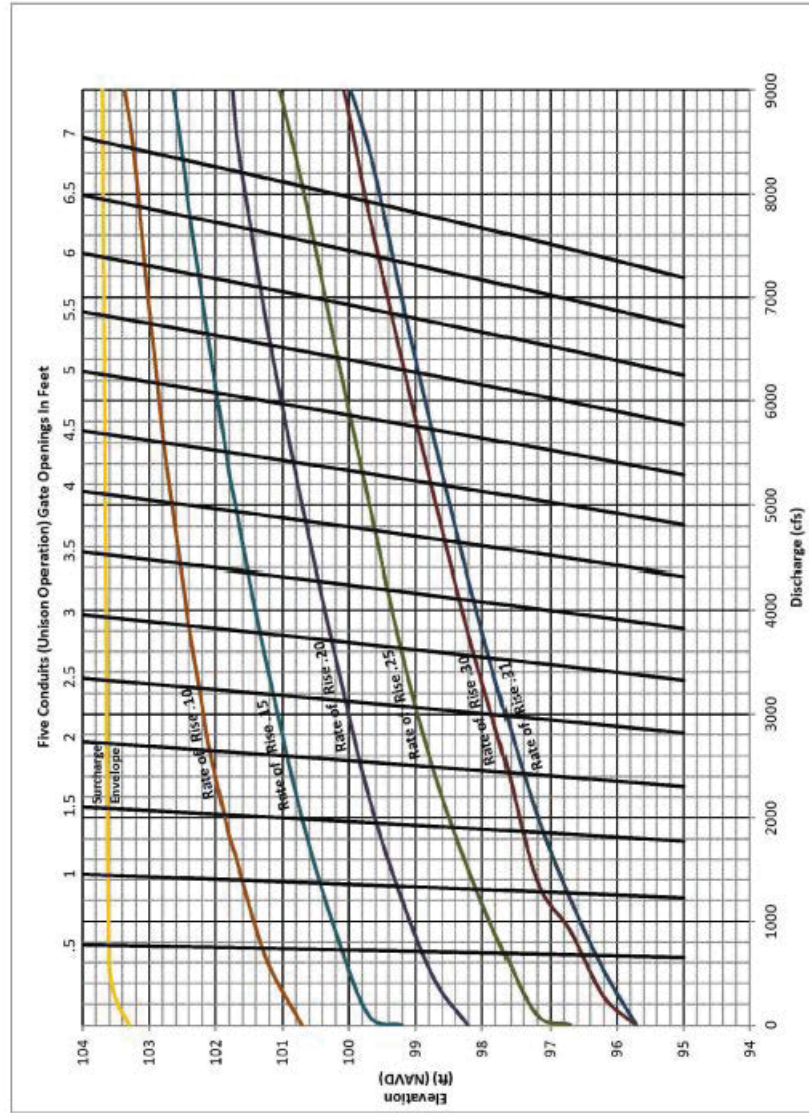
USACE016430



NOTE: RATE OF RISE IS IN FEET/HOUR
 EXAMPLE OF HOW TO READ GRAPH: IF YOU ARE AT ELEVATION 102.8 FT WITH A
 RATE OF RISE OF .35 OPEN FIVE CONDUITS IN UNISON 1.5' OPENING.
 TO DISCHARGE 2000 CFS

| |
|---|
| ADDUCKS AND BARBER RESERVOIR WATER CONTROL MANUAL BUFFALO BRADDOCK LEAS |
| INDUCED SURCHARGE OPERATIONS SCHEDULE ADDUCKS RESERVOIR |
| DAVENPORT DISTRICT, CORPS OF ENGINEERS PLATE 7-03 |

USACE016435



NOTE: RATE OF RISE IS IN FEET/HOUR
 EXAMPLE OF HOW TO READ GRAPH: IF YOU ARE AT ELEVATION 100.4 FT WITH A
 RATE OF RISE OF .15 OPEN FIVE CONDUITS IN UNISON 1 OPENING,
 TO DISCHARGE 1400 CFS

| |
|---|
| ADOCKS AND DAMMED RESERVOIR WATER CONTROL MANUAL BUFFALO BAYOU BASIN, TEXAS |
| INDUCED SURCHARGE REGULATION SCHEDULE BARRIER RESERVOIR |
| CALVESTON DISTRICT, CORPS OF ENGINEERS PLATE 7-04 |

USACE016436

Exhibit 4

FILE COPY

BUFFALO BAYOU AND TRIBUTARIES, TEXAS
ADDICKS AND BARKER DAMS

DAM SAFETY ASSURANCE

**GENERAL DESIGN
MEMORANDUM**



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
JUNE 1984

USACE485914

BUFFALO BAYOU AND TRIBUTARIES, TEXAS
ADDICKS AND BARKER DAMS
DAM SAFETY ASSURANCE
GENERAL DESIGN MEMORANDUM

I INTRODUCTION

1.1 Purpose. - This General Design Memorandum (GMD) presents the plan for the modification of Addicks and Barker Dams to safely pass the Spillway Design Flood (SDF). The present dams are potential safety hazards in light of present day engineering standards, and thus, do not meet Corps of Engineers criteria for dam safety.

1.2 Location. - Barker Dam is located on Buffalo Bayou and Addicks Dam is located on South Mayde Creek, a tributary of Buffalo Bayou. The Buffalo Bayou watershed is tributary to the San Jacinto River and lies primarily in Harris and Fort Bend Counties in southeast Texas. Both dams are located at the western limits of the City of Houston, Texas, as shown on Plate 1.

1.3 Scope. - This GDM contains information on the results of studies and evaluation of various alternatives necessary to select the plan for modification of the dams. The report contains feature design details for raising the main embankment portions of the dams to provide the freeboard necessary to meet dam safety criteria and the general plans for protecting the lower ends of the dams to serve as overflow spillways and prevent erosion. The detailed design information for the main embankments will serve as the basis for preparation of contract plans and specifications. Further design information for protecting the lower ends of the dams will be detailed by subsequent supplemental information.

1.4 Authority for modification. - The modification of Addicks and Barker Dams is to be accomplished under the Dam Safety Assurance Program as prescribed in ER 1130-2-417, dated 30 November 1980, which stipulates that existing project authorities are considered sufficient to permit improvements for safety purposes if such improvements do not alter the scope or function of the project or substantailly change any of its specifically authorized purposes. Authority for preparation of this General Design Memorandum is contained in 2nd Ind. DAEN-CWE-BB (SWGED-DP 29 September 1982), 23 December 1982, Subject: Buffalo Bayou and Tributaries, Texas, Letter Report for Addicks and Barker Dams, Spillways.

1.5 Project authorization and description. - Addicks and Barker Dams were authorized by the 1939 Flood Control Act, a modification of the 1938 River and Harbor Act, House Document No. 456, 75th Congress, 2d Session, which authorized flood control work in the Buffalo Bayou watershed. The project was further modified by the Flood Control Act of 1954, House Document No. 250, 83rd Congress, 2d Session, which authorized straightening, enlarging, and lining where necessary, on Buffalo, Brays, and White Oak Bayous.

1.5.1 Addicks and Barker Dams provide floodwater detention for flood control on the Buffalo Bayou watershed, and, except during periods of heavy rainfall, do not normally impound water. Design data on the dams are given in the

Pertinent Data Sheet in the preface of this GDM. The status of authorized improvements of the Buffalo Bayou and Tributaries project are shown on Plate 1, and discussed in paragraphs 2.1 thru 2.1.2.

1.6 Local cooperation. - There was no cost-sharing or other required local cooperation on the original Addicks and Barker Dams. The Federal Government owns the project lands and operates the dams without contributions from local interests. Thus, under the current authorization, upgrading of the dams for safety would be at Federal expense.

1.7 Datum. - All elevations in this design memorandum are in feet, National Geodetic Vertical Datum of 1929 (NGVD), formerly Sea Level Datum of 1929.

II BACKGROUND INFORMATION

2.1 Historical background. - The original Federally authorized flood control plan for the City of Houston provided for three detention reservoirs (Addicks, Barker, and White Oak). A system of canals was to convey releases from White Oak Reservoir, north of Houston, to the San Jacinto River, and from Addicks and Barker Reservoirs, south of Houston, to Galveston Bay. Also, a levee was to be constructed along the Cypress Creek divide to prevent overflow from the Cypress Creek watershed into Addicks Reservoir. The original design concept for the dams provided for five outlet conduits at each dam, with four of the five to be uncontrolled.

2.1.1 Construction of Barker Dam was initiated in February 1942 and completed in February 1945. During preconstruction planning for Addicks Dam, it was determined to be more economical to increase the capacity of Addicks Reservoir to accommodate the overflow from Cypress Creek and delete the authorized levee. Construction of Addicks Dam was initiated in May 1946 and completed in December 1948. Also, rectification and enlargement of approximately 7.4 miles of the Buffalo Bayou channel immediately downstream of the dams was completed in 1948. However, during construction of Addicks Dam, it was recognized that the planned discharge canals would be delayed because of rapid development in the Houston area. Therefore, in order to provide limited protection downstream on Buffalo Bayou until problems with the discharge canals could be resolved, gates were installed on two of the four uncontrolled conduits at each reservoir.

2.1.2 A review of reports completed in 1952 concluded that rising land costs and rapid development made construction of White Oak Reservoir and the discharge canals impracticable, and, in lieu of these facilities, recommended channel rectification of Buffalo, Brays and White Oak Bayous. These improvements were subsequently authorized by the Flood Control Act of 1954. The plan envisioned straightening and enlarging the channels to contain the Standard Project Flood (SPF) with concrete lining to the level of the 10-year frequency flood. It was rationalized at the time that since the reservoirs provided a measure of flood protection for Buffalo Bayou, priority would be

placed on channel rectification of Brays and White Oak Bayous. Channel improvements for 25.4 miles of Brays Bayou and 10.7 miles of White Oak Bayou were completed in 1971 and 1975, respectively. However, as discussed in paragraphs 16.3 and 16.4 rectification of Buffalo Bayou was delayed by public opposition concerned with aesthetic and environmental effects of the plan on the existing stream. The authorized and completed channel improvements are shown on Plate 1.

2.1.3 The original design concept for both dams provided for four of the five outlet conduits to be uncontrolled, permitting a combined uncontrolled discharge of about 15,700 cubic feet per second (cfs) into Buffalo Bayou. When two of the four ungated conduits were gated at each dam in 1948, the combined uncontrolled discharge was about 7,900 cfs, which was considered to be the channel capacity at that time. Increasing urban development adjacent to Buffalo Bayou during the 1940's and 1950's caused a potential flood threat by the uncontrolled release from the reservoirs. Studies undertaken in 1960 showed the feasibility of gating the remaining uncontrolled conduits and this work was subsequently completed in 1963. The current non-damaging capacity of Buffalo Bayou is about 2,000 cfs, and combined discharges from both reservoirs are limited to this flow rate less tributary inflows below the dams.

2.1.4 The gating of all conduits made it possible to limit discharges from the reservoirs and reduce downstream flooding. However, this control of discharge prolonged storage of rainfall runoff behind the dams and resulted in a serious seepage problem through the pervious sections of the embankments and foundations. This seepage problem threatened the stability of the embankments and created a potential for failure of the dams in the event of a high reservoir pool behind the dams. Repairs for various reaches of the embankments included a bentonite slurry trench seepage barrier extending through the earth fill dams into the relatively impervious clay strata, earthen stability berms placed on the downstream slope of the embankments, and upstream clay blanketing. These emergency modifications discussed in more detail in paragraph 6.5, were completed between 1977 and 1979, at a cost of about \$12 million. The dams now have the capability of storing rainfall runoff for an extended period of time without a threat of failure from seepage.

2.2 Original design criteria. - Addicks and Barker Dams originally were designed to contain and discharge a design flood by uncontrolled releases from the outlet works without endangering the dams; thus, no provisions were made for emergency spillways to discharge large floods. The design storm adopted in the 1940's for the reservoirs was based on the 1935 Houston, Texas, storm with rainfall depths increased by 50 percent. This resulted in a design rainfall of 22 inches in 72 hours. The adopted Spillway Design Flood (SDF) for the reservoirs at that time was the 1899 Hearne, Texas, storm with a time intensity pattern modified to that exhibited by the 1921 Taylor, Texas, storm. This resulted in a design rainfall of 30 inches in 72 hours. The adopted design flood was consistent with criteria applicable at that time for the area to be protected. Also, the original design did not envision the extensive urban development which is rapidly replacing agricultural land uses in the upper watershed, and, thus, increasing the volume of runoff into the reservoirs.

Exhibit 5

SWGED-DP (SWGED-DP 26 Nov 79) 4th Ind
 SUBJECT: Buffalo Bayou and Tributaries - Spillways for
 Addicks and Barker Dams

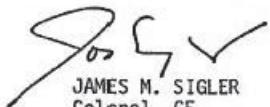
15 AUG 1980

not considered a remote possibility. As an illustration, inclosure 8 discusses transposition of tropical storm "Claudette" over the Addicks and Barker watershed. This storm occurred last year within 40 miles of the reservoirs, and would have resulted in overtopping of Addicks Dam with probable breaching. Finally, inclosure 9 discusses a hypothetical breaching of Addicks Dam. This is not a breach occurring from the "Claudette" storm described above, but rather a combination of assumptions that would produce the worst possible condition on downstream Buffalo Bayou. The table and map attached to inclosure 9 indicate depth and velocities that are extremely hazardous and unacceptable.

8. The plan of action items a thru c contained in 3d Ind SWGED(SWDED-TG 31 Oct 78), subject: Buffalo Bayou and Tributaries - Letter Report for Addicks and Barker Dams, Spillways, dated 5 October 1979 are considered to be complete with submission of this letter. The remaining course of action envisioned, which has been modified to reflect above recommendation, is as follows:

- a. Review and concurrence of SWD and OCE on plan implementation.
 - b. Inform affected local entities, including congressional interests.
 - c. Elicit public views via announcements and workshops.
 - d. Conduct public meetings.
 - e. Implement plan.
9. Approval to proceed in accordance with above recommendations is requested.

- 9 Incl (quad)
1. Resume of GD & SWD Meeting
 2. Description - Plan VI
 3. Map - Plan VI
 4. Description - Plan VI(a)
 5. Map - Plan VI(a)
 6. Map - Hazardous Areas
 7. Summary Table
 8. Transposition of "Claudette"
 9. Breach of Addicks Dam


 JAMES M. SIGLER
 Colonel, CE
 District Engineer

Copy furnished w incl (quad)
 HQDA(DAEN-CWE-BB) Mr. George Lowe RM 6121C

Exhibit 6

Consideration of Alternatives for Preserving
Integrity of Addicks & Barker Reservoirs
Embankments

1. Reference informal note from Mr. Bob James, SWDED-G, 13 Feb 84, concerning SAB.
2. We have assessed the potentials for various emergency actions considering time elements, logistics, availability of personnel and equipment, and practicability of implementation.
3. Our analysis generally follows the referenced informal note and the various actions considered follow:
 - a. Gages and rainfall stations - There are a sufficient number of gages and rainfall stations above Addicks and Barker Reservoirs to forecast reservoir inflows and resultant pool levels. However, receiving data is not assured. A greater assurance of data retrieval will require a ground receive station (Inclosure 1), smart terminal large enough to run models, emergency generator and 3-5 hydraulic engineers.
 - b. Once water starts around the ends, cut ends of dam down to preclude the danger of breaching the high parts of the dam - This alternative was reviewed in detail and it was concluded that the time element involved for degrading was prohibitive.

Inclosure 2 shows the Addicks Dam pool elevation versus time for the PMF on an empty pool. The PMF on an empty pool is considered a probable occurrence when compared with the 1979 Claudette rainfall event which occurred some 40 miles to the south of the reservoirs.

The Reservoir Regulation Manual for Addicks and Barker Reservoirs dictates utilization of the regulation schedules when Addicks' pool reaches 105.8 feet and when Barker's pool reaches 99 feet to assure greater control of major floods. These are also the same elevations the Dam Tender uses for the Emergency Operation Schedule when communications are lost with the District office.

Inclosure 2 indicates there would be about 5 hours between the pool elevation that dictates concern (105.8 feet) and flow around the ends of Addicks Dam and an additional

4.5 hours (9.5 hours total) before overtopping the low ends of the dam. Selection of a lower elevation, 100 feet, would add only 7 hours to the total (16.5 hours). *An analysis of the construction effort and time required to degrade the ends of the dams over reaches of moderate length under adverse conditions indicates a requirement for considerably more hours of work than are available. In summary, the pool rises at such a rate during the PMF that it precludes the possibility of degrading the low ends of the dam.*

c. Modified version of Plan 5b -

(1) Protect high section of dam from progressive erosion of lower sections by establishing hardpoints (riprap or sheet piles) at ends of high sections. Flow around and over the low sections would amount to about 133,800 cfs and 56,000 cfs at the north and southwest ends of Addicks, respectively.

(124,000 cfs at southwest end of Barker.) Flow over the low sections would have a maximum depth of about 1.5 feet and a duration of about 15 hours. *It appears questionable whether this action could be justified based on the depth and duration of the overflow.*

(2) Armor overflow low dam reaches and call it slope protection and access roads. *This action would preclude erosion of the low ends but without increasing the height of the main embankments, a greater*

Exhibit 7

Buffalo Bayou & Tributaries, Texas
Addicks & Barker Reservoirs
Special Report on Flooding
May 1992



**US Army Corps
of Engineers**
Galveston District

First, the crest elevation of major portions of the dams was raised to achieve needed freeboard requirements. Second, erosion protection was added to the lower ends of the dams so the ends can serve as overflow spillways during major storms greater than the Standard Project Flood (SPF) event, up to and including the Probable Maximum Flood (PMF). The above work was accomplished between 1986 and 1989.

RESERVOIR OPERATIONS

The existing plan for reservoir regulation is to operate the reservoirs in a manner that will prevent damaging stages on downstream Buffalo Bayou. This is accomplished by utilizing, to the maximum extent possible, the available storage capacity within the reservoirs. This is in keeping with the original primary objective of flood control for Addicks and Barker Reservoirs.

When there is negligible ponding in the reservoirs, and there is no flooding on downstream Buffalo Bayou occurring nor expected, each reservoir is operated with two gates set at one foot openings. These settings will pass normal low flows and limits the reservoirs' combined discharge to 500 cfs.

Since a downstream portion of the project was never completed, the flow rate in a segment of this reach must be restricted to 2,000 cfs to preclude damages to downstream properties along

Buffalo Bayou. Accordingly, this significantly impacts the allowable release rate from the reservoirs.

When rains occur in the watershed which are insufficient to produce downstream flooding, the reservoir releases are regulated so that their combined releases plus local inflow does not exceed 2,000 cfs. This flow is monitored at the downstream control point, the Piney Point Road gage. This control point is located approximately 11 miles downstream of the dams.

If flooding is predicted or reported downstream, the gates will be closed. The gates will remain closed until downstream conditions permit system releases plus local inflows that remain below the non-damaging capacity. The releases from each reservoir are also regulated so as to achieve an equalization of the available storage within each reservoir.

CURRENT CONDITIONS

When constructed in the 1940's, the reservoirs were located in a rural area at the time. The location was considered to be a substantial distance west of the City of Houston. Land use in and around the reservoirs was predominately farming and ranching. However, in the past 40 years, the extensive urban growth of the western portion of the Houston metropolitan area has resulted in both reservoirs being surrounded by intense commercial and residential development.

The current hydrological design criteria for Addicks and Barker

Exhibit 8



**US Army Corps
of Engineers**
Galveston District

Buffalo Bayou and Tributaries, Texas

RECONNAISSANCE REPORT

Section 216 Study Addicks and Barker Reservoirs Houston, Texas

**U.S. Army Engineer District, Galveston
Southwestern Division
October 1995**

USACE015108

relatively quickly following flood events. Reservoir lands were acquired up to an elevation 3 feet above the pools that would have been produced by the 1935 flood centered over each of the detention basin watersheds. This resulted in the acquisition of land 5.9 feet below the maximum flood control pool elevation at Addicks Reservoir and 8.7 feet below the maximum pool at Barker Reservoir. The difference in the areas of these pools are shown on the attached project map. These government acquisitions were considered an acceptable low-frequency risk because of the relatively remote rural project location.

PROJECT MODIFICATIONS

Five outlet conduits were built at each facility, but only one was originally gated. This permitted a combined uncontrolled flood discharge of 15,700 cubic feet per seconds (cfs). Two additional conduits at each outlet structure required gates in 1948 to reduce reservoir releases. Gates were installed on the remaining two conduits in 1963 because of substantially changed urban conditions. Outlet discharges were significantly reduced from the original design.

The installation of these gates and the need to control outflow has resulted in prolonged ponding in the reservoirs, which was not intended in the original design. This caused seepage through and under the dam embankments in the mid 1970's. Emergency seepage control measures were required for both dams in 1977. These measures consisted of constructing a soil bentonite slurry trench through the embankments and pervious foundations, placement of downstream berms to enhance slope stability, and placement of clay blankets to thicken the impervious cover over pervious foundation materials. This work was completed in 1982.

Additional modifications were made to the dams between 1986 and 1989 to comply with the Dam Safety Assurance Program. The crest elevations of major portions of the dams were raised to achieve needed freeboard requirements for wind-generated wave runup. Erosion protection was

added to the ends of the dams to serve as overflow spillways during major storms greater than the Standard Project Flood (SPF) event, up to and including the Probable Maximum Flood (PMF).

CURRENT RESERVOIR OPERATIONS AND PROCEDURES

Present operations regulate the reservoirs in a manner that prevents damaging stages on downstream Buffalo Bayou. This is accomplished by utilizing, to the maximum extent possible, the available storage capacity within the reservoirs. This is in keeping with the original primary objective of flood control for Addicks and Barker Reservoirs.

When there is negligible ponding in the reservoirs and normal day-to-day conditions exist, each reservoir is set with two conduits at an opening of one foot to pass the normal low flows. Since the downstream portion of the project was never completed, the flow rate in a segment of this reach has been restricted to 2,000 cubic feet per second (cfs) to preclude damages to downstream properties along Buffalo Bayou. When rains occur in the Buffalo Bayou watershed, which are sufficient to produce local runoff, these downstream lateral flows combined with reservoir releases can be no larger than 2,000 cfs. Flows exceeding this limit cause flood damages and are measured by the control point at a gaging station known as Piney Point, located approximately eleven miles downstream of the dams. When this limit is reached, the gates are closed, precluding any releases from the reservoirs. If flooding is predicted or reported downstream, the gates are closed if reservoir conditions dictate. The gates remain closed until downstream conditions permit system releases plus local inflows that remain below the non-damaging capacity. Releases from the reservoirs are regulated based on equalization of the available storage within each reservoir.

PROBLEM IDENTIFICATION

The above described operations and procedures prolong storage of flood waters in the detention facilities and require a longer period of time for complete flood releases. Substantial

erosion damage is now prominent downstream in Buffalo Bayou from long-term low-flow releases. There is also a potential threat of property damage upstream of the reservoir lands. The dams and reservoir lands acquired for upstream temporary reservoir storage are now surrounded by residential and commercial urban developments. Densely populated housing developments essentially fill the fringe areas between the government owned lands (GOL) and the maximum pool elevation adjacent to Addicks Reservoir. Much of the fringe areas of Barker Reservoir are bordered by similar developments and the rest are rapidly developing. Urban development extending for miles upstream from the reservoirs has resulted in increased rainfall runoff into the detention facilities. Recent flood events have clearly identified the need for modification of the reservoir or operational changes. Rainstorms in the spring of 1992 tested the capacity of the reservoirs within the GOL, as shown in Table 1. The impoundments were the highest levels recorded and the rainfall was roughly estimated to have a recurrence frequency of about once in 30 to 40 years. The recent events indicate a potential for future flooding problems.

PLANNED SCOPE OF WORK FOR RECONNAISSANCE STUDY

Prior to study initiation, it was assumed there would be a wide range of feasible alternatives to resolve the problems of the reservoirs. These alternatives are discussed in an Information and Status Report prepared on October 29, 1993, and included in Appendix No. 1. Much of this information is repeated from a prior report entitled Special Report on Flooding, discussed earlier. It documented the existing problems and potential future problems and served as the decision document for including Section 216 study funds in the FY 1994 appropriations. This Special Report is also included in Appendix No. 1. Both reports identify several potentially feasible alternatives that would likely be evaluated in the reconnaissance study. These alternatives are briefly described as follows:

- Increase reservoir flood storage by excavation on GOL;

- Increase reservoir flood storage by purchase of flowage easements in the fringe areas adjacent to GOL over existing developed properties;
- Increase reservoir storage capacity by means of buy-out and relocation of developed properties;
- Reduce reservoir inflows by increasing upstream storage on undeveloped lands located above existing urban developments;
- Increase reservoir flood releases by buy-out of downstream damageable properties;
- Increase reservoir flood releases by enlargement of the downstream Buffalo Bayou channel;
- Increase reservoir flood releases by installation of additional outlet works and diversion of flows to streams other than Buffalo Bayou;
- Increase reservoir flood releases and reduce prolonged storage by changing the current operating plan;
- Adopt a flood warning and evacuation plan; and
- Accept existing conditions and risk through No Action.

ACTUAL SCOPE OF WORK PERFORMED

A review of existing hydrologic conditions and the economic field surveys indicated that the resulting lack of average annual flood damages have eliminated essentially all of the alternative solutions listed above. The level of protection now provided and the frequency of future damageable flooding under present urban development have produced this situation. Hydraulic studies under present operating conditions show that Addicks Reservoir has adequate GOL to contain floods up to a frequency of about once in 250 years. Barker Reservoir, however, has GOL to contain floods up to about once in 70 years. Although Barker Reservoir was filled to eighty percent of capacity on GOL from record flooding in 1992, as shown in Table No. 1, it still provides a high level of flood protection. Average annual damages above this level do not provide adequate

RECOMMENDATIONS

It is recommended that this Section 216 study of Addicks and Barker Reservoirs be terminated because of insufficient economic benefits to justify project modification, as addressed in this Reconnaissance Report. It is further recommended that no further Federal actions be taken leading to feasibility-level investigations. It is suggested that other means be pursued to update the 1977 hydrologic data to confirm the findings discussed herein.

The Reconnaissance Report is being submitted according to the latest instruction found in Planning Guidance Letter 95-03, dated 1 August 1995. This process is described in the transmittal letter. It is recommended that the procedure be followed for completion of this authorization.

16 OCT 95

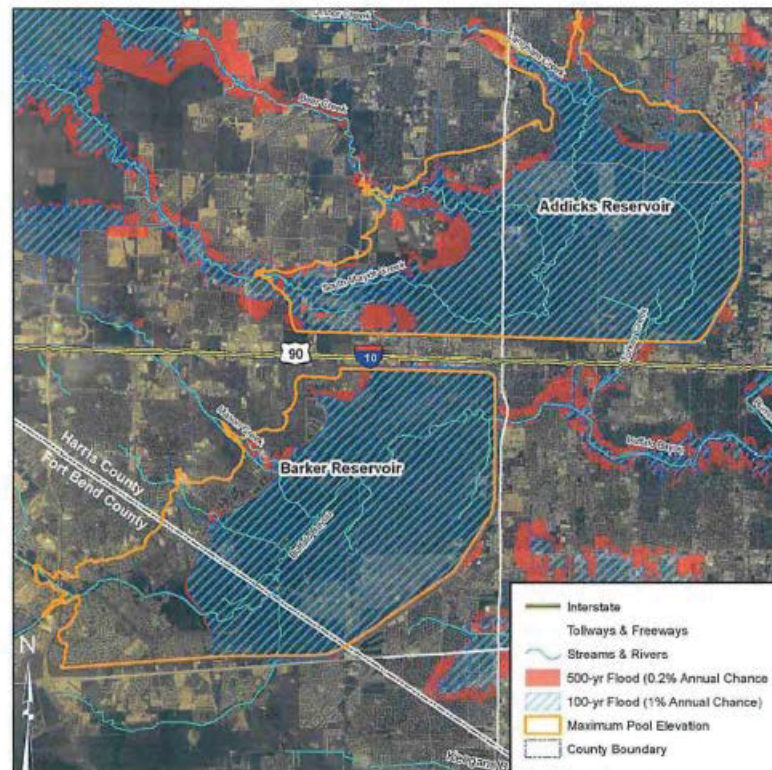


Robert B. Gatlin
Colonel, Corps of Engineers
District Engineer

Exhibit 9

**DRAFT OPERATIONAL ASSESSMENT OF THE ADDICKS AND
BARKER RESERVOIRS, FORT BEND AND HARRIS COUNTIES, TX**

OCTOBER 2009



**U.S. ARMY CORPS OF
ENGINEERS
GALVESTON DISTRICT**

SPONSOR:



**HARRIS COUNTY
FLOOD CONTROL
DISTRICT**

USACE464067

Identification of Problems and Opportunities

Overview

The review of available information has identified several water resource problems related to the operation and performance of the Addicks and Barker Reservoir system. The following paragraphs summarize these problems as they relate to:

- Operational Constraints
- Upstream Impacts
- Downstream Impacts

Operational Constraints

The current operating procedure for the Reservoirs is to monitor rainfall information, radar data and the stream gages and then make the decision to close or open the gates based on the downstream flow rate at Piney Point and the rainfall prediction. Since it is important to evaluate operational and security issues at the site, gate controls are not automated. (Personal Communication USACE, 2009).

The increase in downstream development (and possibly downstream tributary inflow) has contributed to reductions in allowable outflows. The dams are operated strictly to prevent downstream flooding; therefore, the gates remain shut even if pool levels increase and flood upstream properties. The flood pools have never exceeded the limit of GOL and the homes upstream of the dams have not flooded due to the pool. However, available hydrologic models indicate that the limit of GOL would be exceeded in extreme events; for example, it is believed that if Tropical Storms Allison or Claudette had been centered on the basin, flooding of the upstream development would have occurred.

A current hydrologic/reservoir simulation model was not available for this evaluation. The reservoirs currently experience a problem during successive storm events because they do not empty fast enough under the current 2,000 cfs flow restriction to allow adequate storage capacity, making upstream flood damage a possibility. Based on interviews with field operations personnel, it can take two to three weeks after a flooding event until the reservoirs are completely emptied. Barker Reservoir has slightly more capacity than Addicks Reservoir, based on the dam elevations (209,000 acre-feet versus 200,800 acre-feet), but the GOL capacity is much lower in the Barker Reservoir (83,500 acre-feet versus 116,000 acre-feet). Addicks Reservoir is currently estimated to have capacity for a 200-year event without flooding beyond the GOL, but Barker Reservoir only has capacity for a 70-year event within the GOL.

As noted earlier, the downstream discharge limit of 2000 cfs results in the reservoirs being drained very slowly and limits the storage available for subsequent flood events. The 1992 flood event provides an example of the potential loss of storage. Prior to the rainfall of 7.68 inches recorded at the Barker gage on March 4, 1992, Barker Reservoir pool held 42,260 acre feet, approximately 50% of the storage available within the GOL.



Alternatives Considered

Previous reports obtained from the USACE and HCFCD were reviewed to identify alternatives to be considered (See Table 4). The alternatives discussed in these reports were screened to eliminate those alternatives that were deemed to be too costly (deep tunnel diversion) or environmentally unacceptable (Buffalo Bayou channel enlargement). These alternatives were supplemented by several additional options to address the problems identified. These additional alternatives were developed based on various project meetings. The paragraphs below provide brief summary of the alternatives.

Operational Alternatives

The first array of alternatives is considered have the lowest impact and require no physical construction. These alternatives are also likely to have the shortest timeline for implementation and could provide short term benefits even if long term solutions are identified and implemented.

Prioritizing Release from Barker Reservoir

This alternative seeks to address the relatively higher risk of flooding beyond the limits of GOL in Barker Reservoir to reduce the potential flood damage to properties along the reservoir fringe. In the Section 216 Study, this alternative looked at prioritizing releases from the smaller Barker Reservoir in order for it to be prepared for the next event. Outflow discharge routings indicate that Barker Reservoir GOL could achieve 100-year protection while having minor reduction effects on the capacity of Addicks Reservoir. This change in operation would increase the duration of high pool levels in Addicks Reservoir and result in more frequent flooding and longer duration closure of SH6. Also the backwater effects of higher flooding over SH6 would increase the potential for damages to a large number of structures located in the Addicks Reservoir fringe area during extremely rare events. Calculations presented in the Section 216 study show that additional time value delay caused by closure of SH6 was estimated at \$20,000 per year in 1995 dollars. Flooding along the fringe area in Addicks Reservoir would cost about \$19,000 per year. These induced damages would nearly offset the damage reduction in Barker Reservoir resulting in only a small net benefit.

Revising the Release Procedure to Increase Post-Storm Discharge

The current procedure is to prevent downstream flooding and protect downstream properties. During a flooding event, the gates are closed and the reservoir levels are allowed to rise until they overflow the spillways. Since there is development adjacent to the GOL, these structures would be flooded during an extreme event. As noted earlier, there is significant development within the fringe area between the GOL and the maximum pool elevation. With such high valuation of upstream properties, it might be desirable to increase the allowable release rates from the reservoir once the downstream peak flows have occurred, and accept some increased duration of downstream flooding. The higher flow rates would be established at less than the rate that would cause flood damage to downstream structures or restrict access to key roadways. A review of the HEC-RAS hydraulic model, profiles, cross sections and National Weather Service (NWS) flood warning data suggests that the flow rate could be increased to 2,500 cfs, possibly higher. As seen in Figure 5, this would correspond to a stage of about 42 ft NAVD at the Piney Point gage, compared to the NWS action stage of 49 and flood stage of 52 and peak historic flood elevations of 61.23 ft on 03/04/1992 and 60.98 ft on 04/28/2009. While the revision of the operating procedures to increase the post storm release rate appears reasonable, the reasons for the current 2,000 cfs release rate



Exhibit 10

CESWG PLAN 500-1-3
22 May 2014

ANNEX I (ADDICKS & BARKER EMERGENCY ACTION PLAN) TO EMERGENCY
OPERATIONS PLAN

EMERGENCY ACTION PLAN

ADDICKS RESERVOIR
NID # TX00018

AND

BARKER RESERVOIR
NID # TX00019

BUFFALO BAYOU AND TRIBUTARIES

**US ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS**



FOR OFFICIAL USE ONLY (FOUO)

CESWG PLAN 500-1-3
22 May 2014

**APPENDIX E TO ANNEX I (ADDICKS & BARKER EMERGENCY ACTION PLAN) TO
EMERGENCY OPERATIONS PLAN**

**Water Elevation Impact Tables
Addicks Water Elevation Impact Table**

| <u>Elevation¹</u> <u>(Feet)</u> | <u>Surface</u> <u>Area²</u> <u>(Acres)</u> | <u>Capacity³</u> <u>(Acre-</u> <u>Feet)</u> | <u>Capacity⁴</u> <u>(Percent)</u> | <u>Impacts</u> |
|---|---|--|---|---|
| 87.5 | 7 | 35 | 0 | Invert of Conduit Outlet Structures |
| 87.0 | 2,122 | 6,905 | 3 | Stage 1 Extended Watch begins |
| 87.8 | 2,485 | 8,280 | 4 | Low point Patterson Road |
| 88.8 | 3,212 | 11,679 | 6 | Low point Bear Creek Drive |
| 88.9 | 3,278 | 12,004 | 6 | Adverse effects begin on golf course |
| 92.9 | 6,103 | 30,931 | 15 | 2 year flood frequency Shelter slab elevations in Bear Creek Park |
| 95.7 | 7,809 | 50,301 | 25 | 5 year flood frequency |
| 96.0 | 8,027 | 52,677 | 26 | Low point on State Hwy 6 |
| 96.5 | 8,436 | 56,792 | 28 | 10 year flood frequency |
| 96.6 | 8,519 | 57,640 | 29 | Low point Eldridge Parkway High point on State Hwy 6 |
| 96.9 | 8,771 | 60,233 | 30 | High point on Eldridge Parkway Water Control notifies Emergency Management that this trigger has been reached Implement notification of Stage 2 Extended Watch response personnel to prepare to deploy Logistics to identify Stage 2 Extended Watch response vehicles |
| 97.46 | 9,189 | 65,264 | 33 | Stage 2 Extended Watch Maximum pool to date, 09 March 1992 |
| 97.5 | 9,218 | 65,633 | 33 | 25 year flood frequency |
| 98.4 | 9,906 | 74,232 | 37 | 50 year flood frequency |
| 100.3 | 11,397 | 94,500 | 47 | 100 year flood frequency |
| 101.0 | 11,879 | 102,646 | 51 | 80% of Government owned land Coordination required see Appendix C: Reservoir Regulation |
| 101.2 | 12,002 | 105,034 | 53 | First street flooded upstream |
| 103.0 | 13,016 | 127,591 | 64 | Limits of government owned land |
| 103.4 | 13,201 | 132,834 | 67 | First home inundated upstream |
| 103.8 | 13,387 | 138,151 | 69 | Low point Barker-Cypress Road |
| 107.5 | 15,764 | 191,652 | 96 | Standard Project Flood |
| 108.0 | 16,199 | 199,643 | 100 | Natural ground at north end of dam |
| 111.5 | 18,574 | 260,646 | | North spillway elevation |
| 112.0 | 18,858 | 270,003 | | Natural ground at west end of dam |
| 114.5 | 20,592 | 319,301 | | West spillway elevation |
| 115.0 | 20,910 | 329,676 | | Spillway design flood |
| 121.0 | 24,609 | 467,064 | | High point of dam |

CESWG PLAN 500-1-3
22 May 2014

**APPENDIX E TO ANNEX I (ADDICKS & BARKER EMERGENCY ACTION PLAN) TO
EMERGENCY OPERATIONS PLAN**

Barker Water Elevation Impact Table

| <u>Elevation¹</u> <u>(Feet)</u> | <u>Surface</u> <u>Area²</u> <u>(Acres)</u> | <u>Capacity³</u> <u>(Acre-</u> <u>Feet)</u> | <u>Capacity⁴</u> <u>(Percent)</u> | <u>Impacts</u> |
|---|---|--|---|---|
| 70.2 | 0 | 0 | 0 | Invert of conduit outlet structures |
| 82.7 | 1,040 | 2,330 | 1 | Low point Barker-Clodine Road |
| 85.0 | 2,279 | 6,081 | 3 | Stage 1 Extended Watch begins |
| 88.9 | 5,801 | 20,881 | 10 | 2 year flood frequency |
| 89.2 | 6,417 | 22,703 | 11 | Adverse impacts on baseball fields |
| 89.7 | 7,706 | 26,229 | 13 | Adverse impacts on American Shooting range |
| 90.4 | 9,191 | 32,209 | 15 | Adverse impacts on Model Airport |
| 91.7 | 10,644 | 45,332 | 22 | 5 year flood frequency |
| 92.7 | 11,188 | 56,258 | 27 | 10 year flood frequency Water Control notifies Emergency Management that this trigger has been reached Implement notification of Stage 2 Extended Watch response personnel to prepare to deploy Logistics to identify Stage 2 Extended Watch response vehicles |
| 93.21 | 11,396 | 62,026 | 30 | Edge of Westheimer Parkway |
| 93.4 | 11,444 | 64,195 | 31 | 25 year flood frequency Low point Beeler road |
| 93.5 | 11,469 | 65,341 | 31 | 80% of Government owned land Coordination required see Appendix C: Reservoir Regulation |
| 93.6 | 11,494 | 66,489 | 32 | Stage 2 Extended Watch Maximum pool to date, 07 Mar 1992 |
| 93.9 | 11,569 | 69,949 | 33 | 50 year flood frequency |
| 94.9 | 11,991 | 81,719 | 39 | First street flooded upstream in Fort Bend County |
| 95.0 | 12,036 | 82,921 | 40 | 100 year flood frequency Limits of government owned land |
| 96.6 | 12,451 | 102,483 | 49 | First street flooded upstream in Harris County |
| 97.1 | 12,638 | 108,750 | 52 | First home inundated upstream in Harris County |
| 98.1 | 13,259 | 121,698 | 58 | First home inundated upstream in Fort Bend County |
| 99.0 | 13,813 | 133,879 | 64 | Standard Project Flood |
| 104.0 | 16,543 | 209,600 | 100 | Natural ground at both ends of dam |
| 105.1 | 17,267 | 228,182 | | North spillway elevation |
| 106.7 | 18,412 | 256,737 | | West spillway elevation |
| 108.0 | 19,330 | 281,267 | | Spillway design flood |
| 113.1 | 21,278 | 384,832 | | High point of dam |

Exhibit 11



REPLY TO
ATTENTION OF
CESWG-EC-DL

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O BOX 1229
GALVESTON, TEXAS 77553-1229


27 October 2017

MEMORANDUM FOR Commander, Southwestern Division, (CESWD-RBT, Michael Southern)

SUBJECT: Addicks and Barker Dams, Houston, Texas, New Pool of Record

- 1 Addicks and Barker Dams both set a new pool of record on 30 August 2017 of 109.09 feet (NAVD88) and 101.56 feet (NAVD88) respectively. This was due to Hurricane Harvey stalling over the Addicks and Barker reservoir watershed producing 32-35 inches of rain from 25 – 29 August 2017. Galveston District engineers were on site monitoring around the clock under the Stage 2 Extended Watch alert in accordance with the Addicks and Barker Dams' Emergency Action Plan (EAP). Visual observations, photographic evidence, and instrumentation readings were recorded. The enclosed report documents the project's performance for the new pool of record in accordance with the requirements of ER 1110-2-1156, Safety of Dams, Policy and Procedures, 31 March 2014.
- 2 The embankment, outlet structures, and emergency spillways functioned as intended. Piezometers, settlement pins, and alignment surveys for the outlet structures do not shown any alarming trends from this pool of record. There were no observations of seepage, or critical distress areas located on the dams. Wet areas located on the downstream embankment toe were monitored, but showed no signs of flow. Erosion of the dam and cofferdam crest became an issue for inspection teams trying to transverse them. Overall conclusion is that the project was performing as expected with no significant problems during this pool of record event.

Encl
1. Report of Performance


Robert C. Thomas, P.E.
Chief, Engineering and Construction Division
Galveston District Dam and Levee Safety Officer

Digitally signed by
THOMAS, ROBERT CHARLES, U.S. Government
DN: cn=THOMAS, ROBERT CHARLES, ou=USACE, ou=USA,
c=US, email=ROBERT.CHARLES@USACE.army.mil
Date: 2017.10.27 10:52:25 -0500

CF:
Chief, Operations (CESWG-OD-O, Karl Brown)

USACE016689

Exhibit 12

Report of Performance

Addicks & Barker Dams

New Pool of Record

UNITED STATES ARMY CORPS OF ENGINEERS, GALVESTON DISTRICT

May 11, 2016

Authored by: Gary Chow, P.E. SWG. DSPM

USACE207226

Report of Performance

Addicks & Barker Dams

The Addicks and Barker dams' watersheds received between 10-17 inches of rain during a 24 hours period on April 18, 2016 and also additional rain between 0.5-1.7 inches throughout the rest of the week. Addicks and Barker Dams were practically empty prior to this rain event. On April 23, 2016, both Addicks & Barker dams reached new maximum pool of records at El. 102.65' and El. 95.2', respectively. The previous maximum pool of records for Addicks and Barker Dams were at El. 97.5' and El. 93.6', respectively.

In accordance with the Emergency Action Plan (EAP) for Addicks and Barker Dams, Stage 2 Extended Watch alert was activated when the previous maximum pool of records were exceeded on April 18, 2016. Teams of foundation observers were mobilized from the Galveston District to the site within 6 hours of the exceedances of maximum pool of records to monitor the performance of the dams around the clock. The 24/7 monitoring event was conducted from April 18, 2016 through May 10, 2016 until the pools receded to Stage 1 Extended Watch levels.

During the high pool event, several major thoroughfares inside the reservoirs were closed due to high water inundation. These major thoroughfares included Highway 6 and Eldridge Parkway across Addicks Dam, and Westheimer Parkway and South Barker-Cypress Road across Barker Dam. Some residential streets flooding also occurred on the upstream side of both dams during the peak levels in the reservoirs.



A deviation of release request for the dams was approved for a combine release of 4,000 cubic feet per second (cfs) measured at Piney Point approximately 10 miles downstream of the dams. Teams of hydrologic observers were also dispatched from the Galveston District to monitor the area flooding conditions from the rain event both upstream and downstream of the dams, and any potential impact from the 4,000 cfs releases to the downstream areas along Buffalo Bayou. Any impacts from the approved deviation releases of 4,000 cfs were found to be minimal.



This report provides the findings and evaluation of the dam performance during the exceedance of the previous maximum pool of record. It is prepared and submitted in accordance with ER 1110-2-1156, Safety

Exhibit 13



CWMS Forecast: 8/23/2017

The Addicks and Barker Reservoirs fully emptied yesterday after maintaining a pool for about 2 weeks due to the August 7/8 rain event. The gates are at standard settings currently, allowing reservoir inflows to pass through. The 7-day QPF is showing accumulations of approximately 16.5 inches.

With rainfall beginning Friday and continuing through Monday, the 16.5 inches will take pool elevations close to the government owned land limits. Extended Watch, Stage 1 levels will be exceeded Saturday and Extended Watch, Stage 2 levels will be exceeded Sunday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

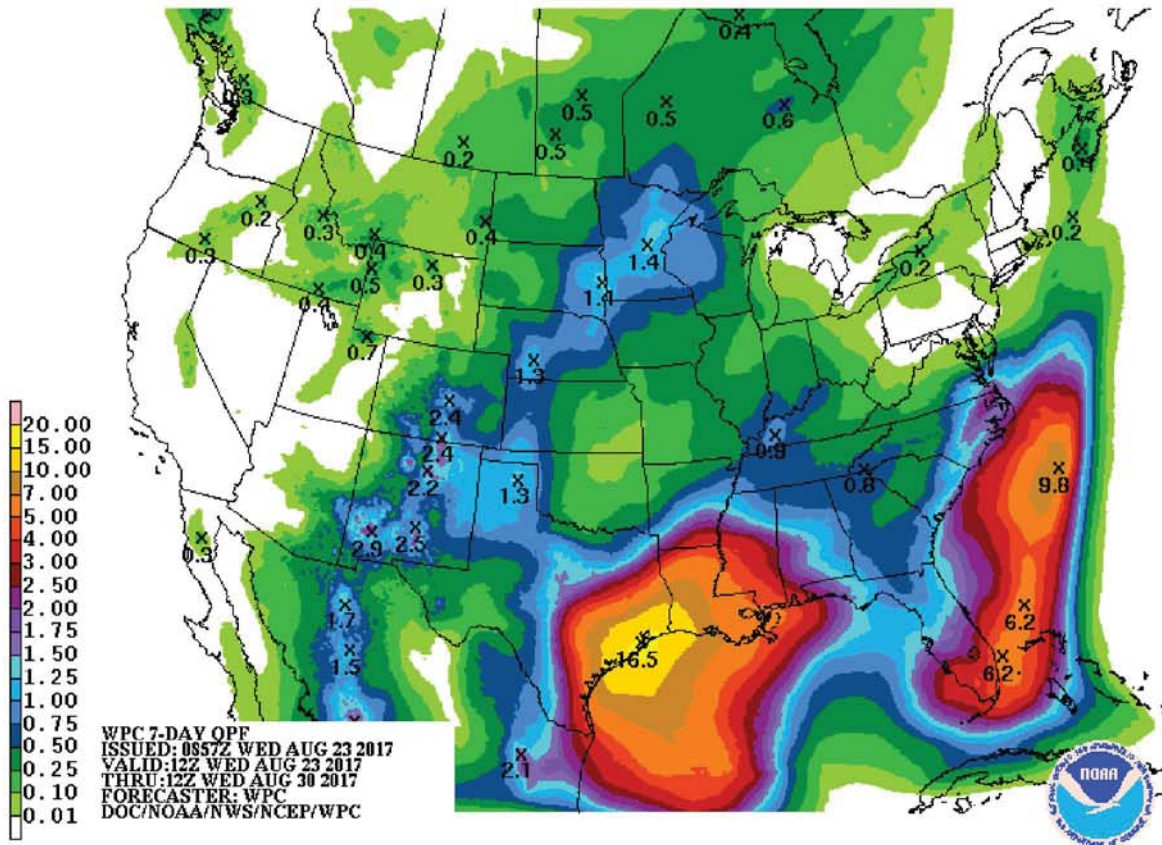
| Forecast Summary for QPF | | |
|---------------------------------------|-----------|-----------|
| | Addicks | Barker |
| Peak Forecasted Res. Level (ft, NAVD) | 103.2+ | 97.2+ |
| Time of Peak Res. Level | 8/30/2017 | 8/30/2017 |
| EW, Stage 1 Res. Level (ft, NAVD) | 87.0 | 85.0 |
| Extended Watch, Stage 1 Forecasted? | Yes | Yes |
| EW, Stage 2 Res. Level (ft, NAVD) | 97.46 | 93.6 |
| Extended Watch, Stage 2 Forecasted? | Yes | Yes |

Forecast Information:

- Forecast Start Time: 8/23/2017 09:00
- Lookback Period: 7 days
- Forecast End Time: 8/30/2017
- Data Sources
 - NexRad
 - Manual QPF
- Starting reservoir levels
 - Addicks: 69.34 ft (NAVD)
 - Barker: 71.90 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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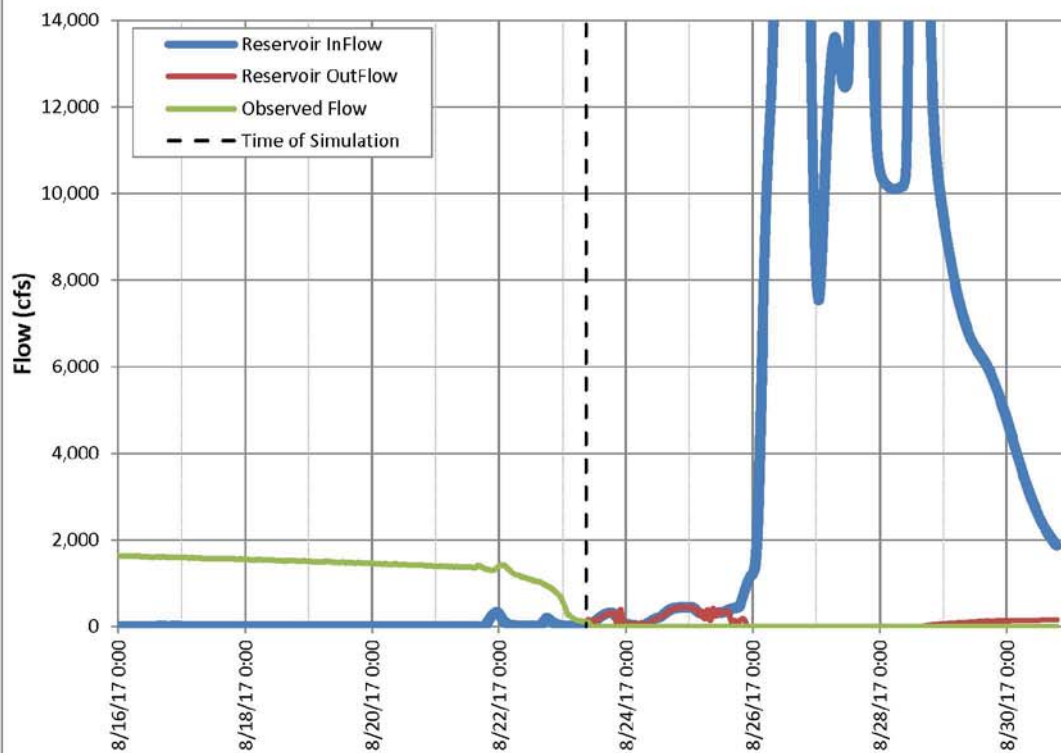
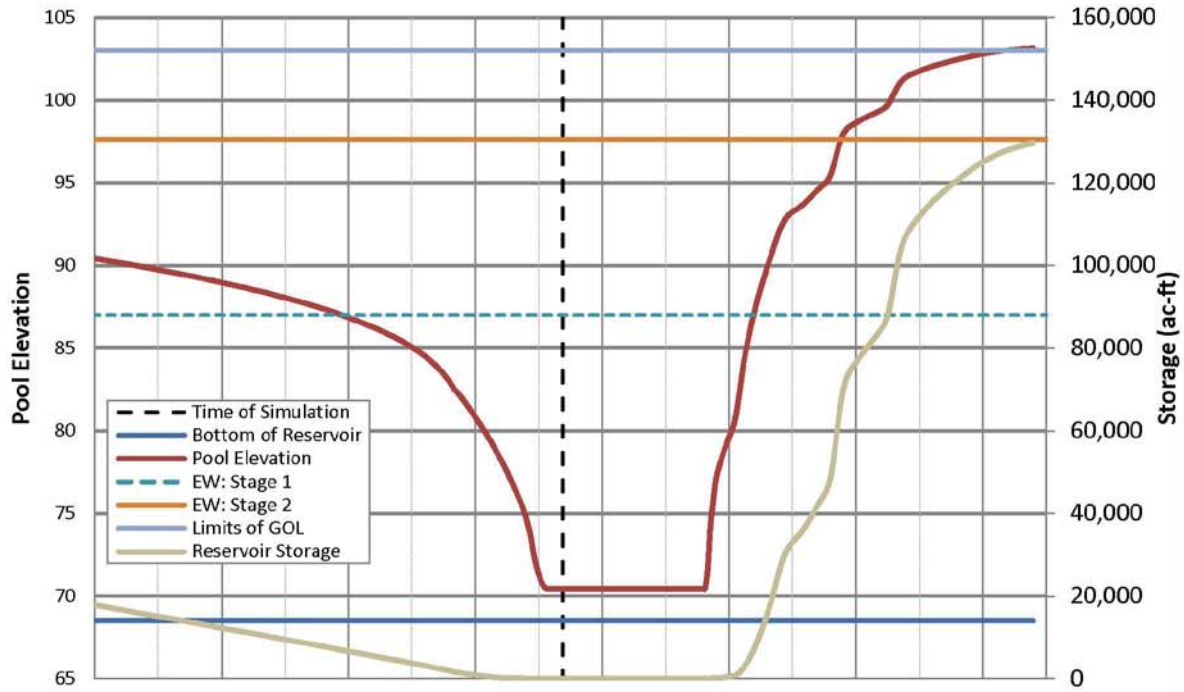
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

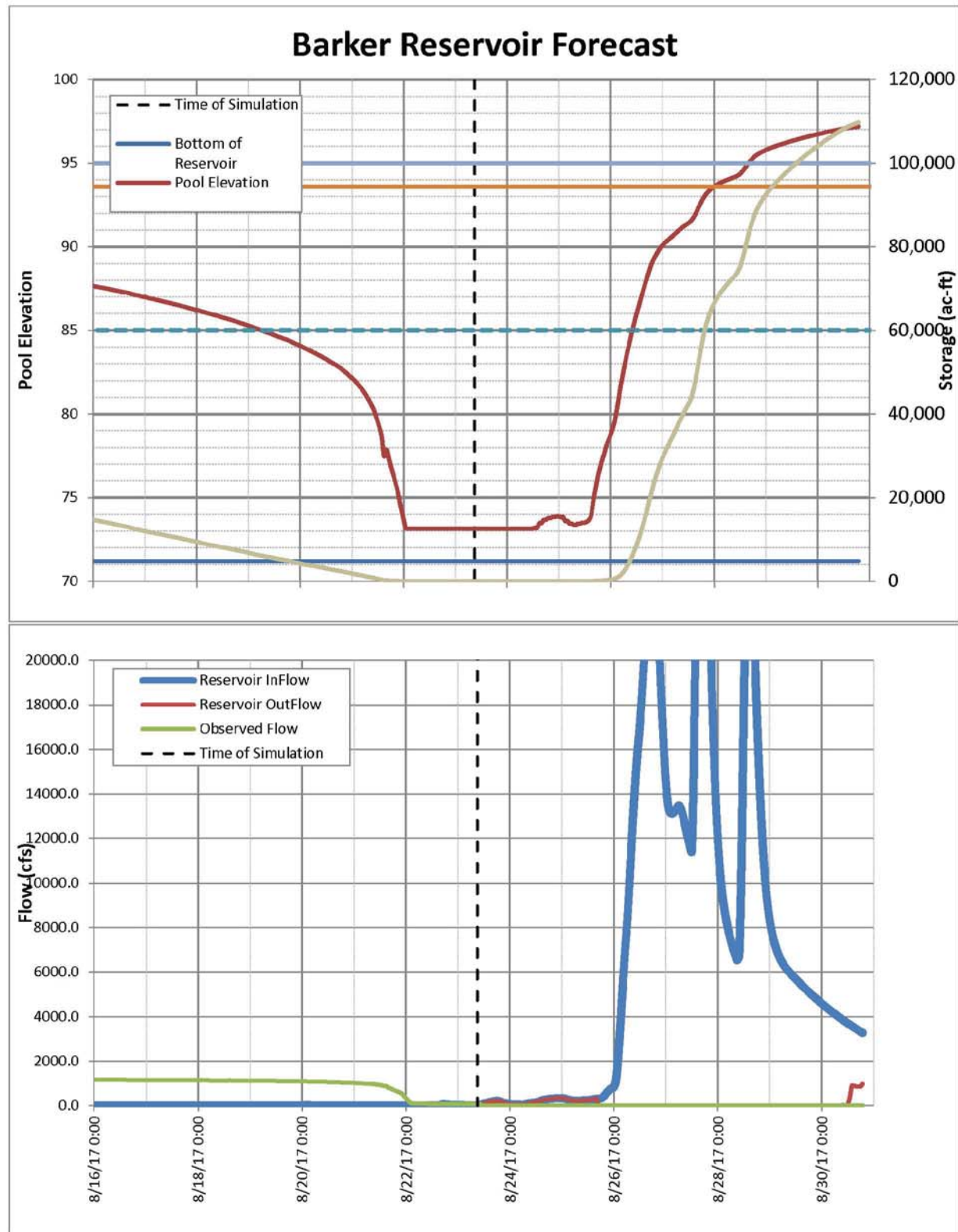
Page 3 of 4

Forecasted on:
23-Aug-17

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CWMS Forecast: 8/24/2017

The Addicks and Barker Reservoirs are fully empty and the gates are at standard settings, allowing daily reservoir inflows to pass through. The 7-day QPF is showing accumulations of approximately 16.5 inches.

With rainfall beginning Friday and continuing through Monday, the 16.5 inches will take pool elevations close to the government owned land limits. Extended Watch, Stage 1 levels will be exceeded Sunday and Extended Watch, Stage 2 levels will be exceeded by Monday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

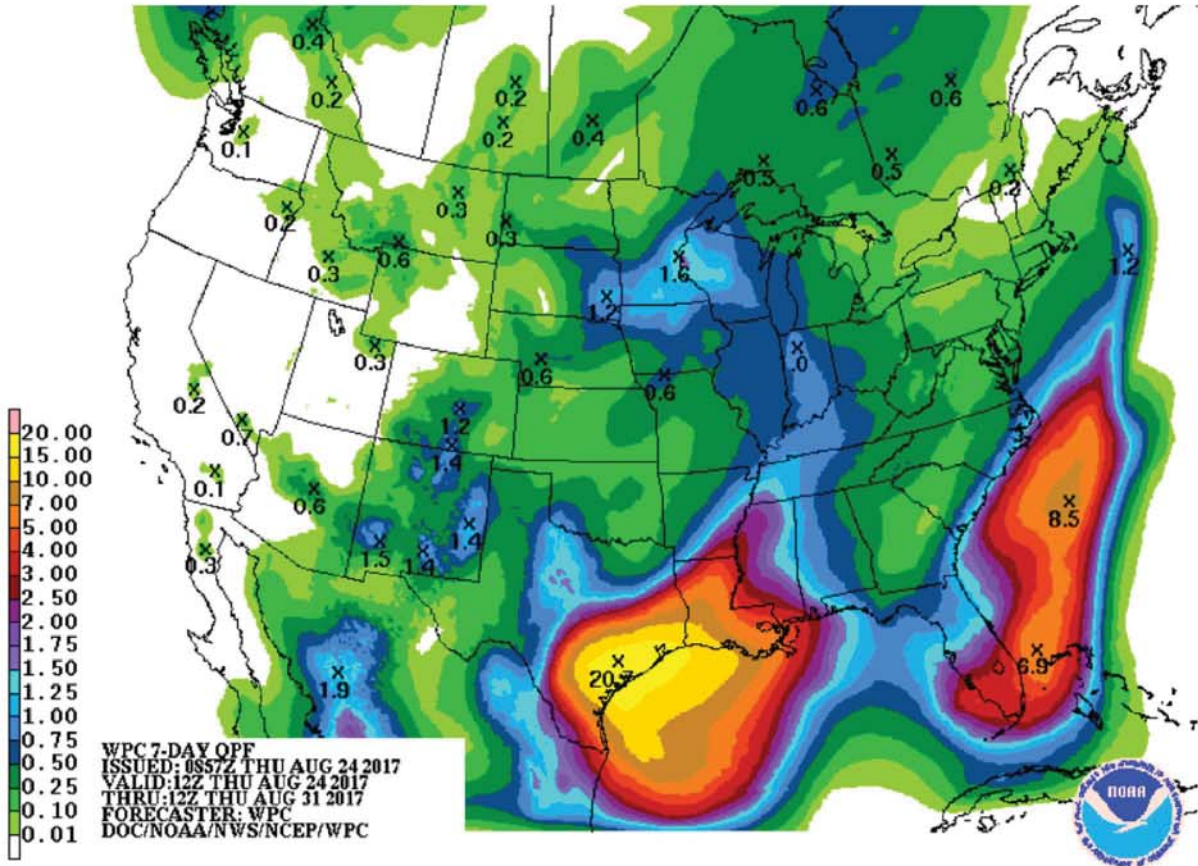
| Forecast Summary for QPF | | |
|---------------------------------------|--------------------|--------------------|
| | Addicks | Barker |
| Peak Forecasted Res. Level (ft, NAVD) | 103.3 | 98.5 |
| Time of Peak Res. Level | 01 Sep 2017, 17:00 | 03 Sep 2017, 09:00 |
| EW, Stage 1 Res. Level (ft, NAVD) | 87.0 | 85.0 |
| Extended Watch, Stage 1 Forecasted? | Yes | Yes |
| EW, Stage 2 Res. Level (ft, NAVD) | 97.46 | 93.6 |
| Extended Watch, Stage 2 Forecasted? | Yes | Yes |

Forecast Information:

- Forecast Start Time: 8/24/2017 07:00
- Lookback Period: 7 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Manual QPF
- Starting reservoir levels
 - Addicks: 70.45 ft (NAVD)
 - Barker: 73.15 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M3ODXMGK

Page 2 of 4

Forecasted on:
24-Aug-17

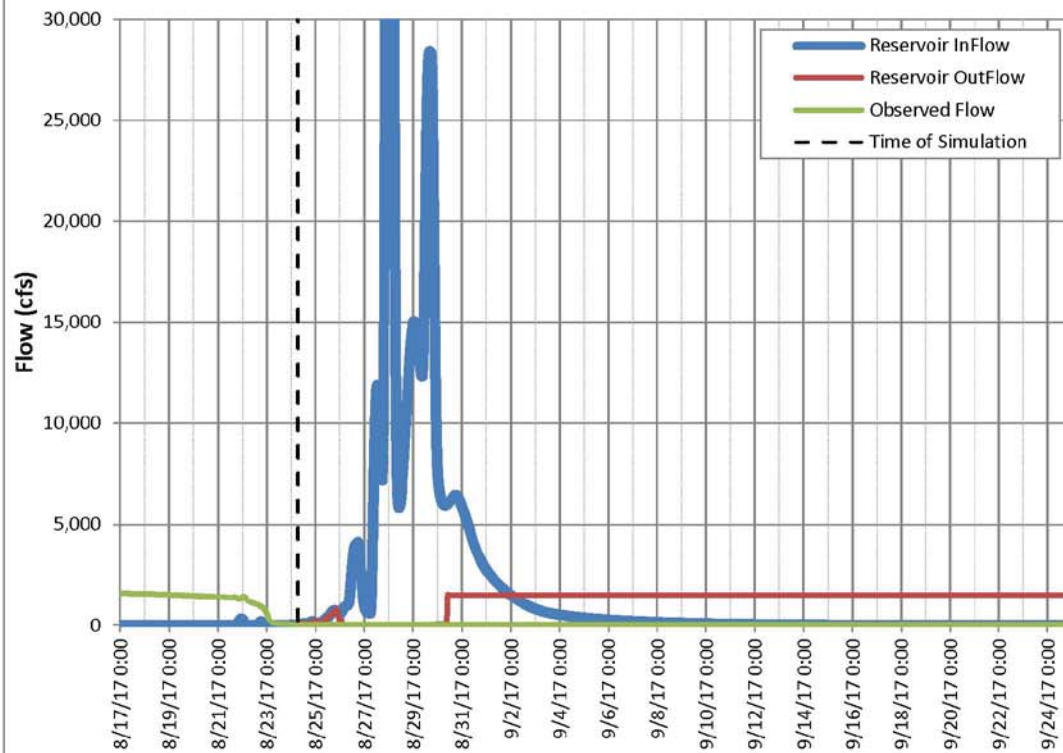
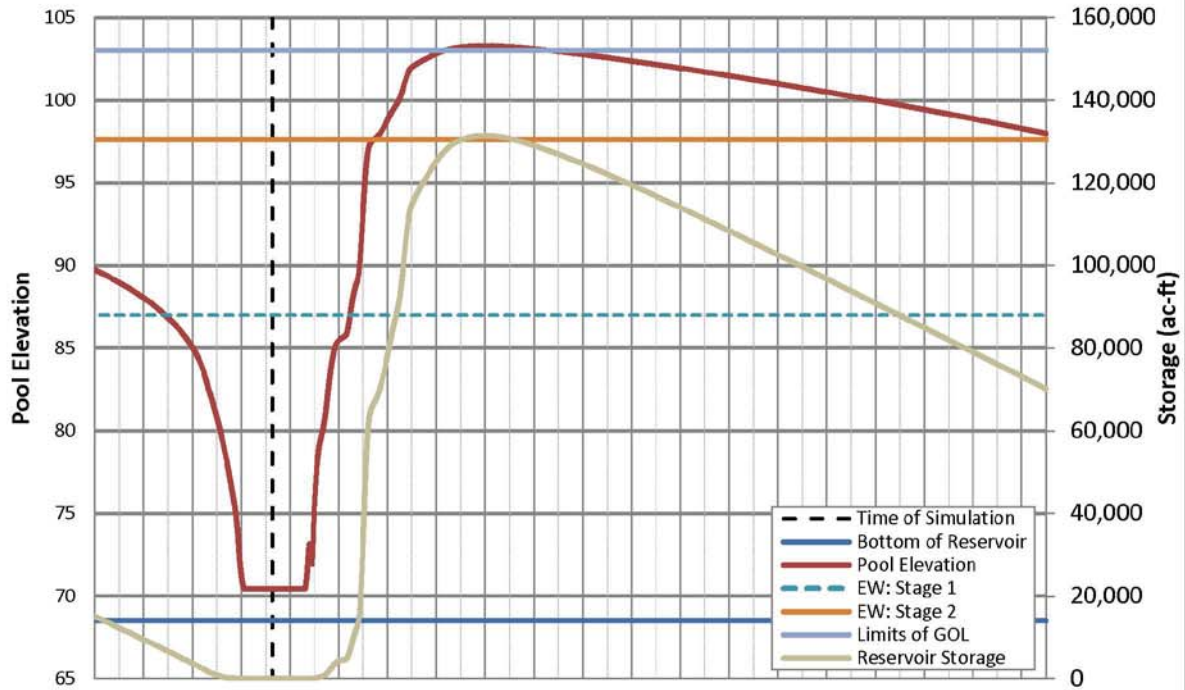
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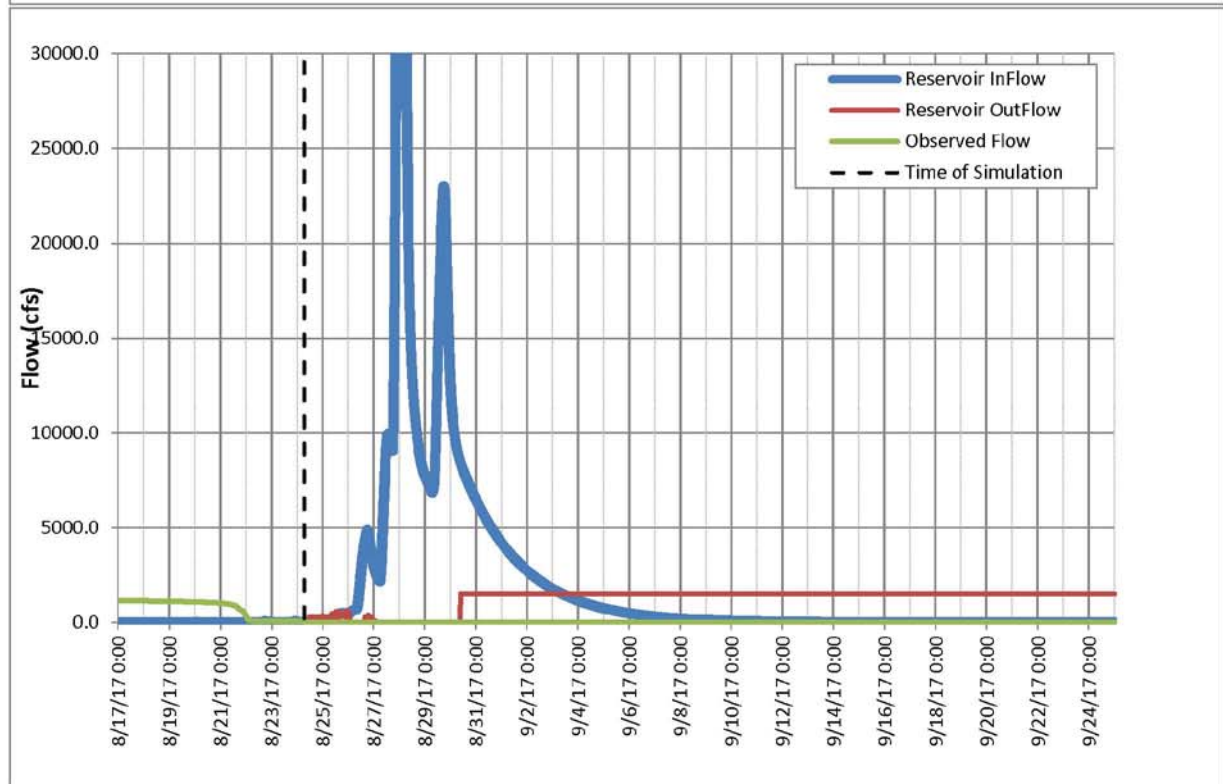
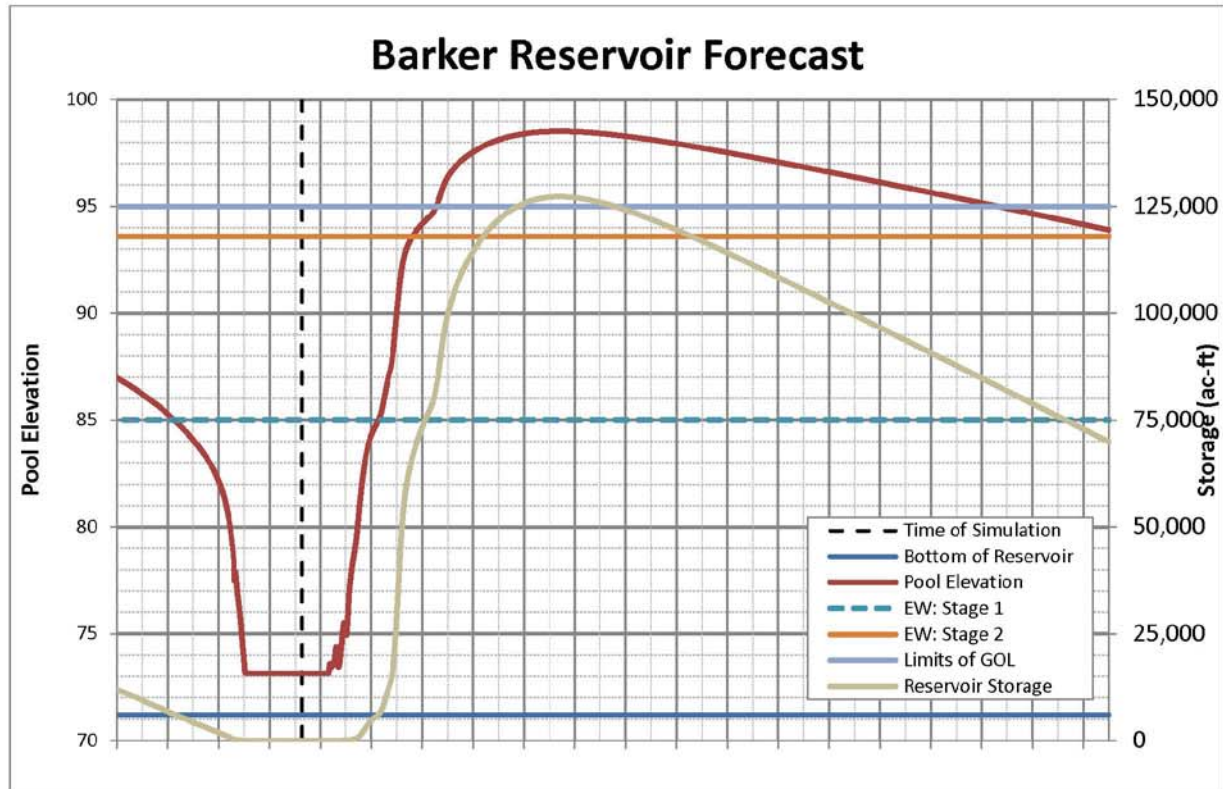


Addicks Reservoir Forecast



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CWMS Forecast: 8/25/2017

The Addicks and Barker Reservoirs are fully empty and the gates are at standard settings, allowing daily reservoir inflows to pass through. The 7-day QPF is showing accumulations of approximately 23 inches.

With rainfall beginning later today and continuing through Monday, the 23 inches will take pool elevations beyond the government owned land limits. Extended Watch, Stage 1 levels will be exceeded Saturday and Extended Watch, Stage 2 levels will be exceeded by Monday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

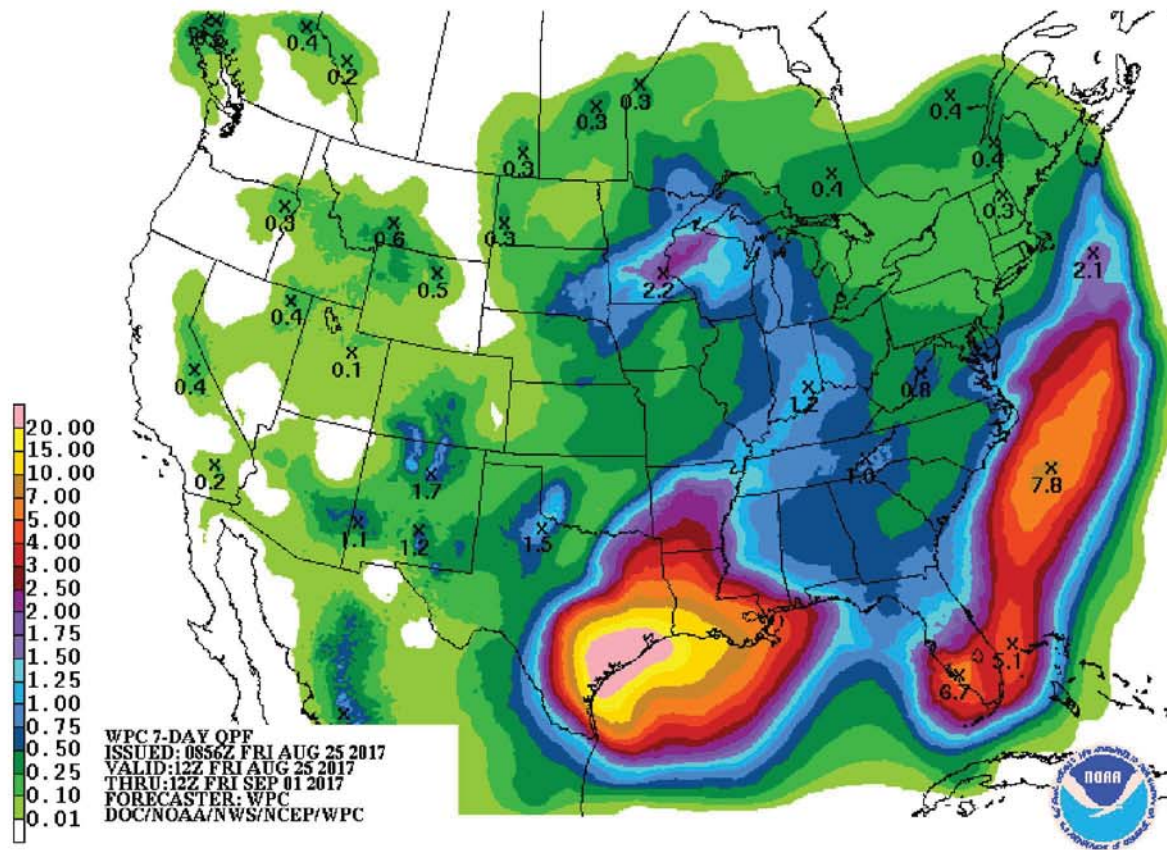
| Forecast Summary for QPF | | |
|---------------------------------------|--------------------|--------------------|
| | Addicks | Barker |
| Peak Forecasted Res. Level (ft, NAVD) | 105+ | ~ 100 |
| Time of Peak Res. Level | 01 Sep 2017, 20:00 | 04 Sep 2017, 09:00 |
| EW, Stage 1 Res. Level (ft, NAVD) | 87.0 | 85.0 |
| Extended Watch, Stage 1 Forecasted? | Yes | Yes |
| EW, Stage 2 Res. Level (ft, NAVD) | 97.46 | 93.6 |
| Extended Watch, Stage 2 Forecasted? | Yes | Yes |

Forecast Information:

- Forecast Start Time: 8/25/2017 07:00
- Lookback Period: 7 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Manual QPF
- Starting reservoir levels
 - Addicks: 69.0 ft (NAVD)
 - Barker: 71.87 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
25-Aug-17

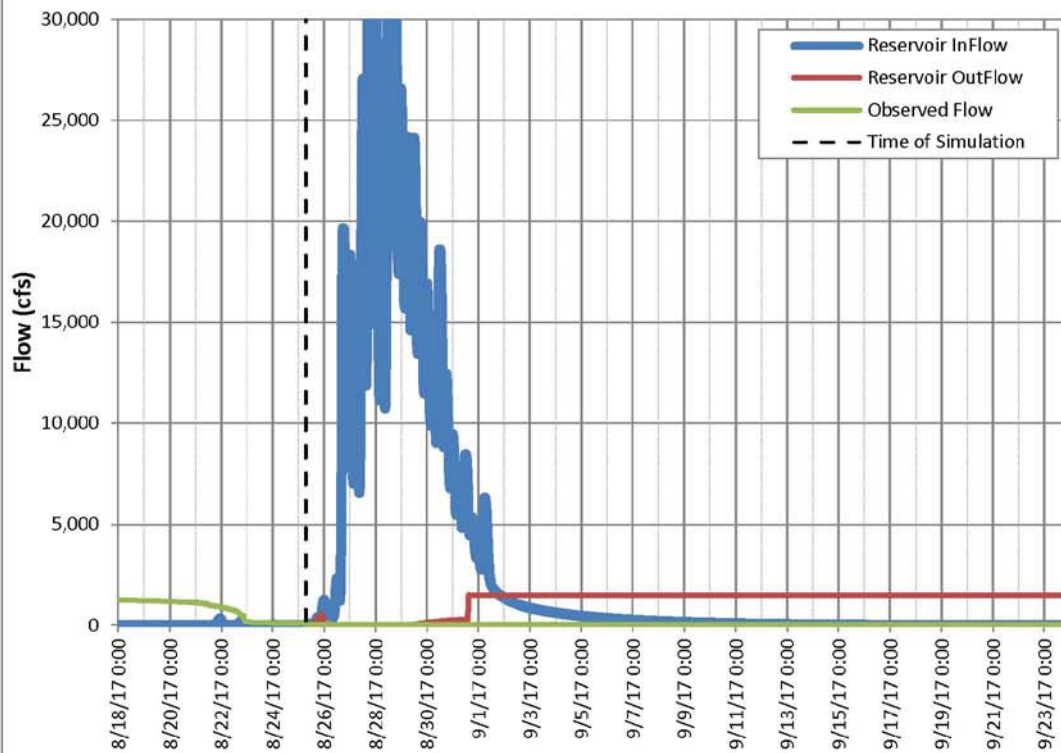
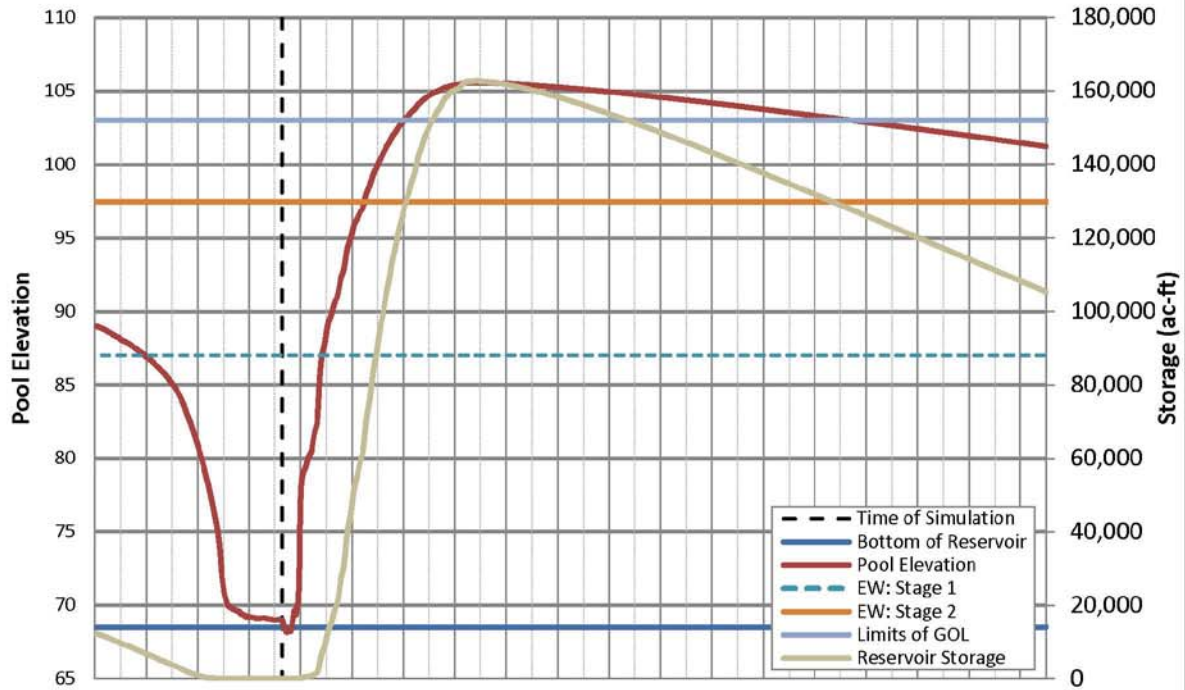
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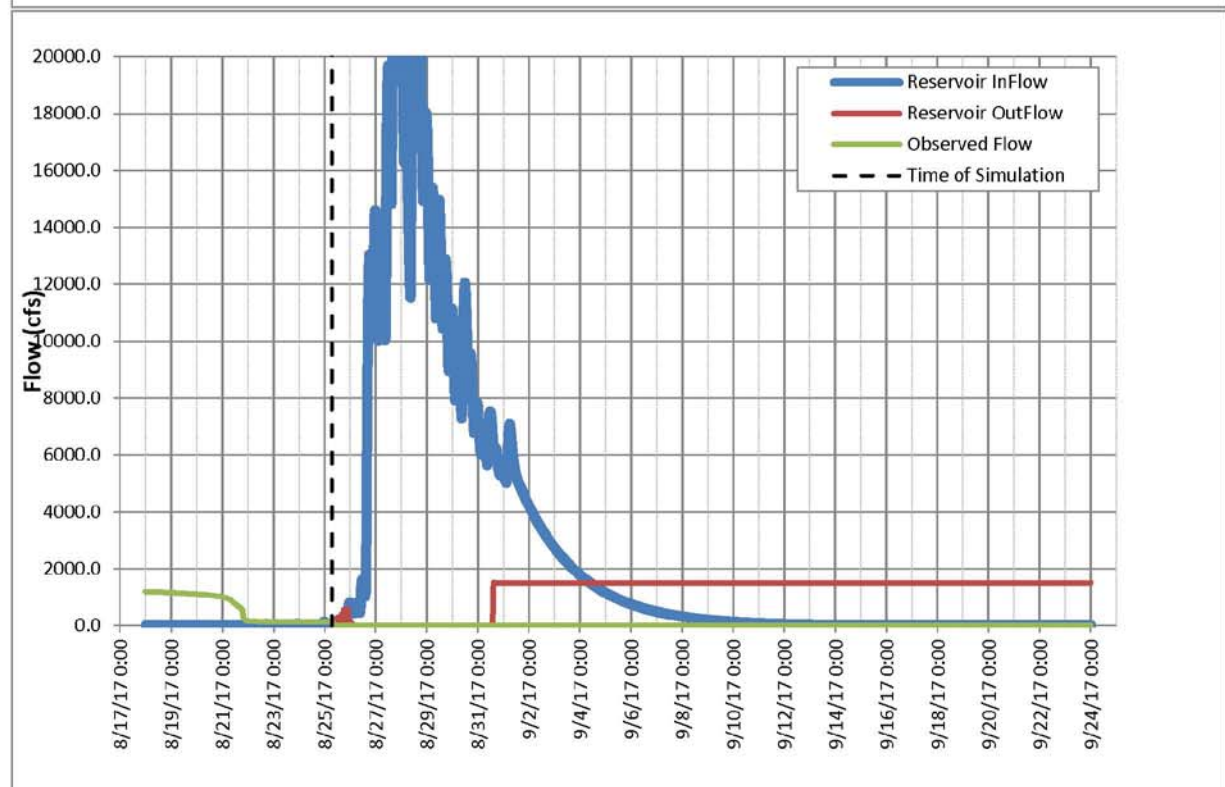
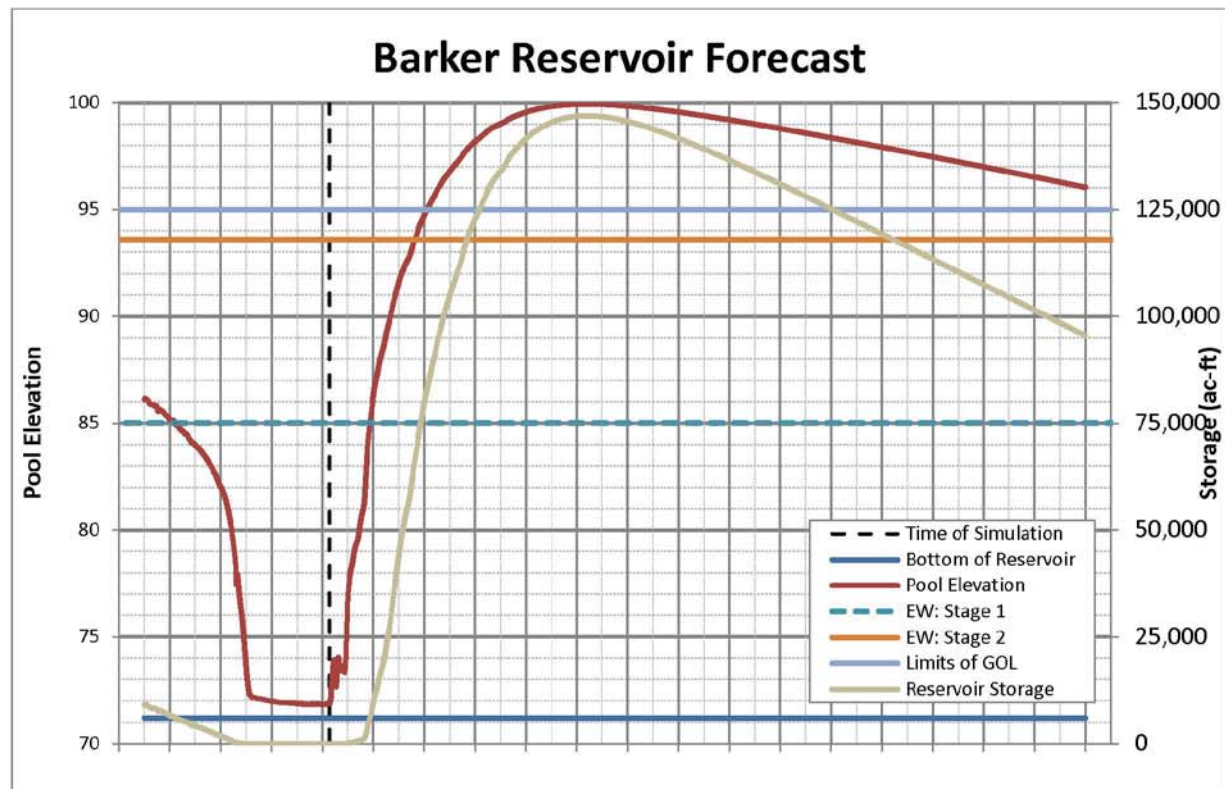


Addicks Reservoir Forecast



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CWMS Forecast: 8/26/2017

The Addicks and Barker watersheds have received 3-5 inches across the watersheds in the last 24 hours. Gates were closed last night. Forecasted rainfall amounts are in flux. The 7-day accumulation assumed for this forecast is approximately 30-inches as received from the River Forecasting Center.

With rainfall continuing over the next 5+ days, the reservoirs are expected to exceed record pools. At this time, we are not expected to make mandatory releases for surcharge operations. This forecast assumes releases from Addicks Reservoir can begin on September 1 and then balanced releases at both reservoirs on September 6. A deviation is still in effect allowing flows in Buffalo Bayou to approach 4,000 cfs.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

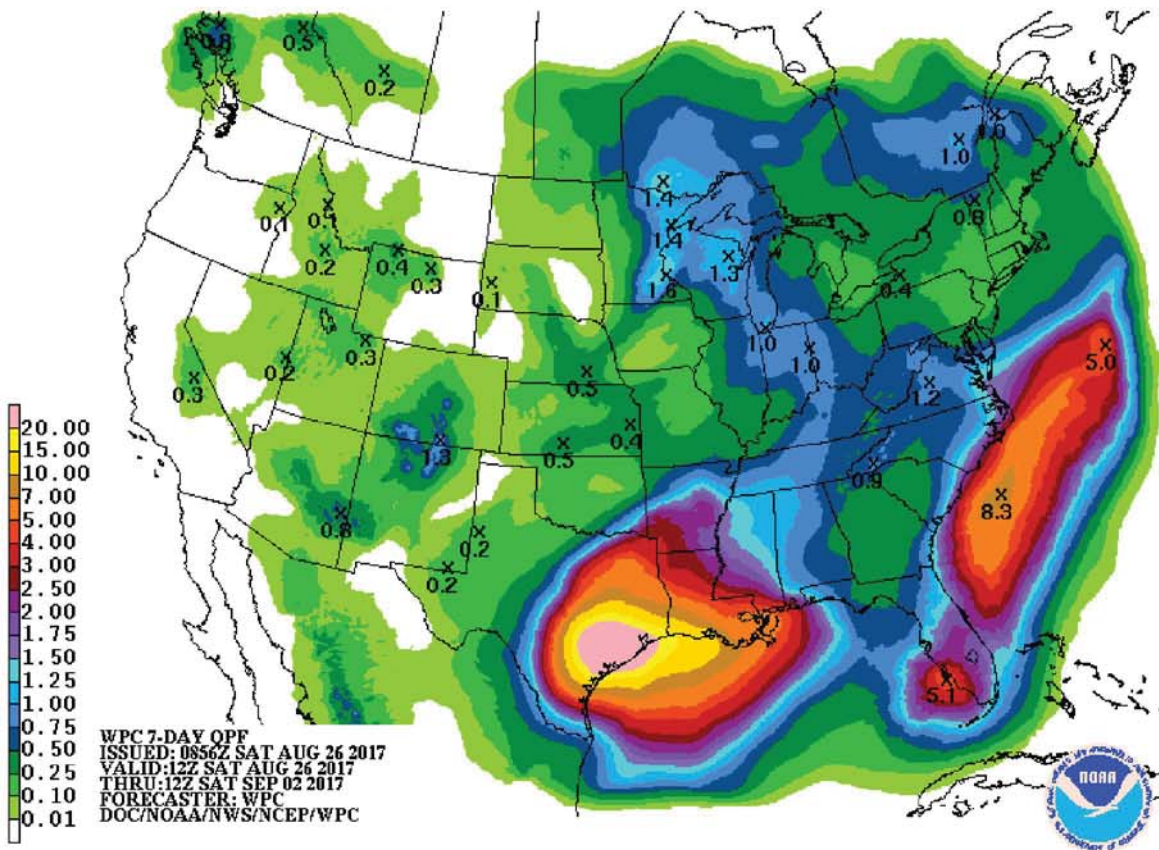
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 16:00 | 94.46 | 26 Aug 2017, 15:00 |
| EW, Stage 2 Res. Level | 85 | 27 Aug 2017, 14:00 | 93.5 | 27 Aug 2017, 15:00 |
| Government Owned Land | 103 | 28 Aug 2017, 18:00 | 95 | 27 Aug 2017, 22:00 |
| first home flooded | 103.4 | 29 Aug 2017, 20:00 | 97.1 | 28 Aug 2017, 16:00 |
| End of Dam | 108 | 30 Aug 2017, 24:00 | 104 | not forecasted |
| Peak | 108.4 | 01 Sep 2017, 11:00 | 103.41 | 06 Sep 2017, 18:00 |

Forecast Information:

- Forecast Start Time: 8/26/2017 05:00
- Lookback Period: 10 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 76.34 ft (NAVD)
 - Barker: 77.52 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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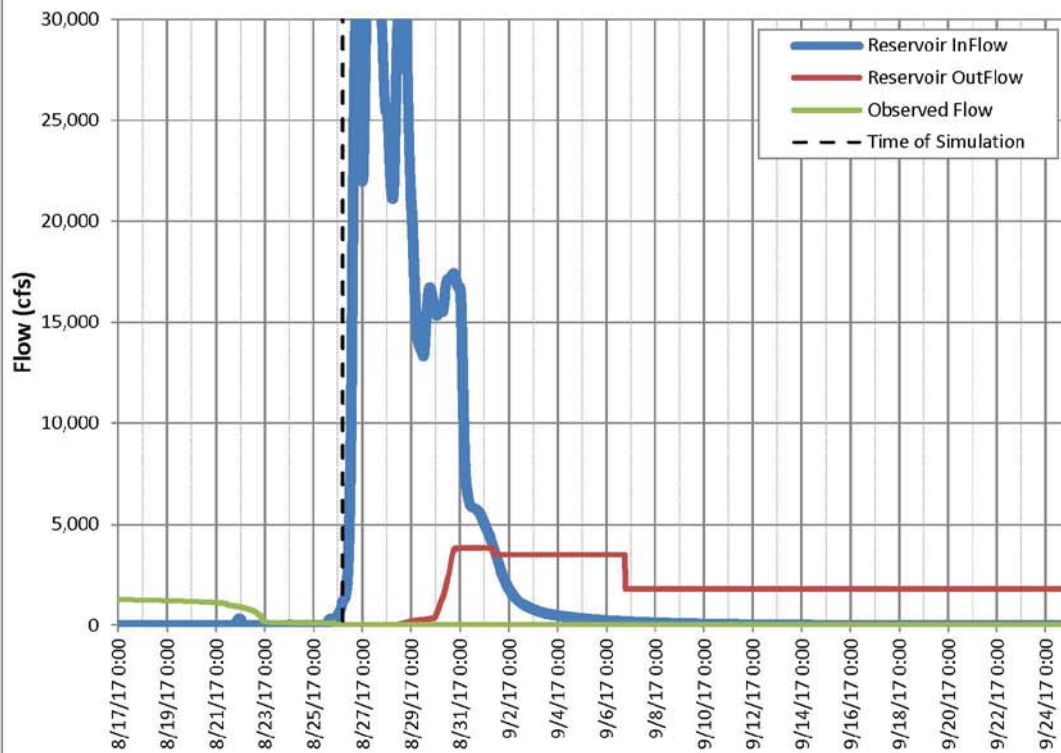
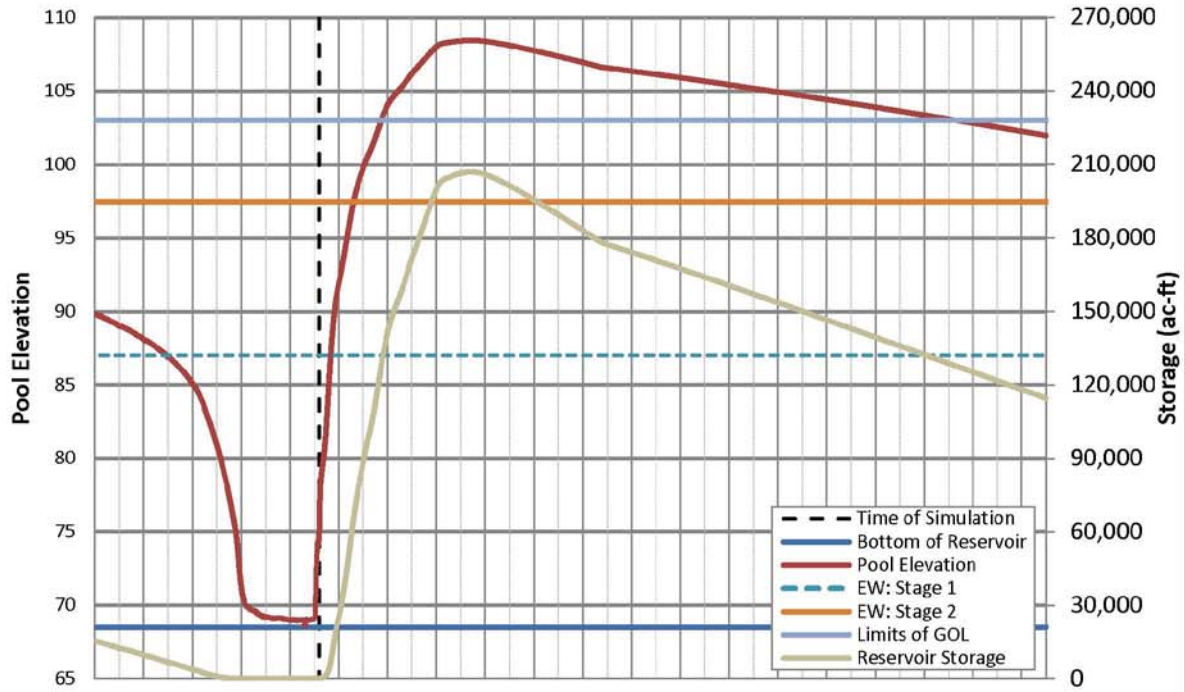
7-day QPF

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Galveston District

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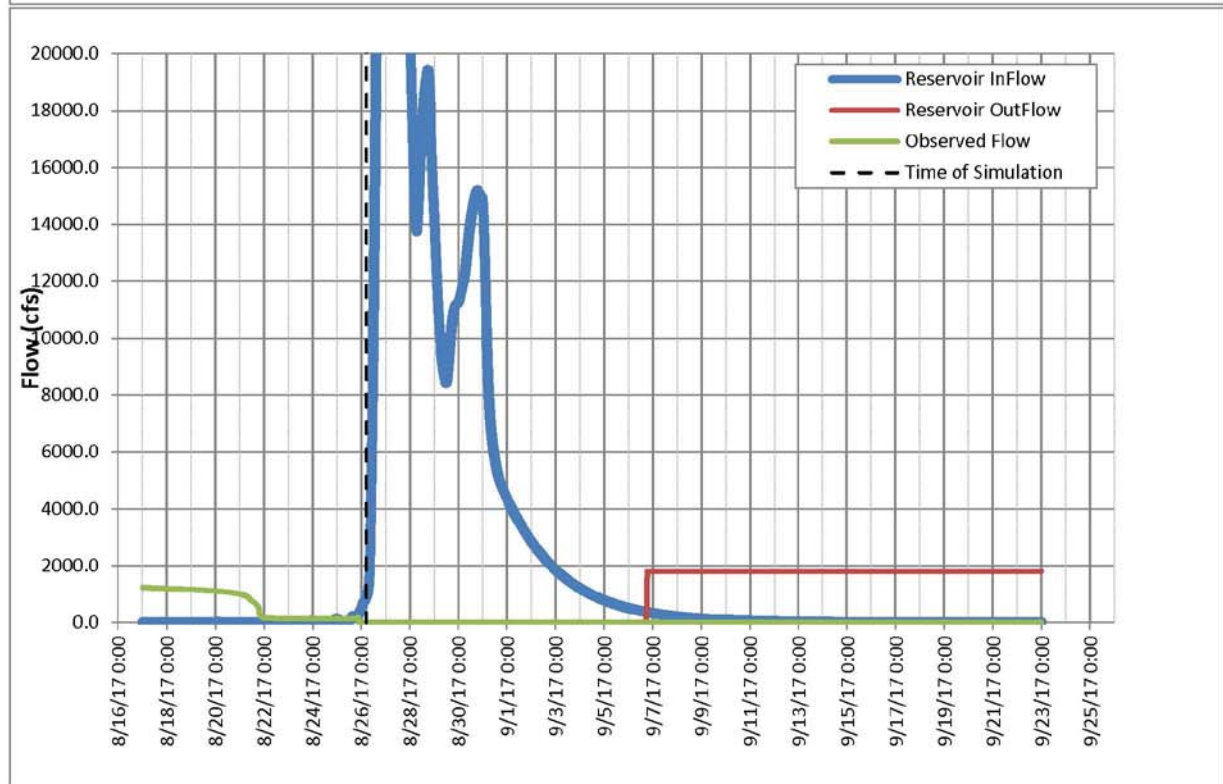
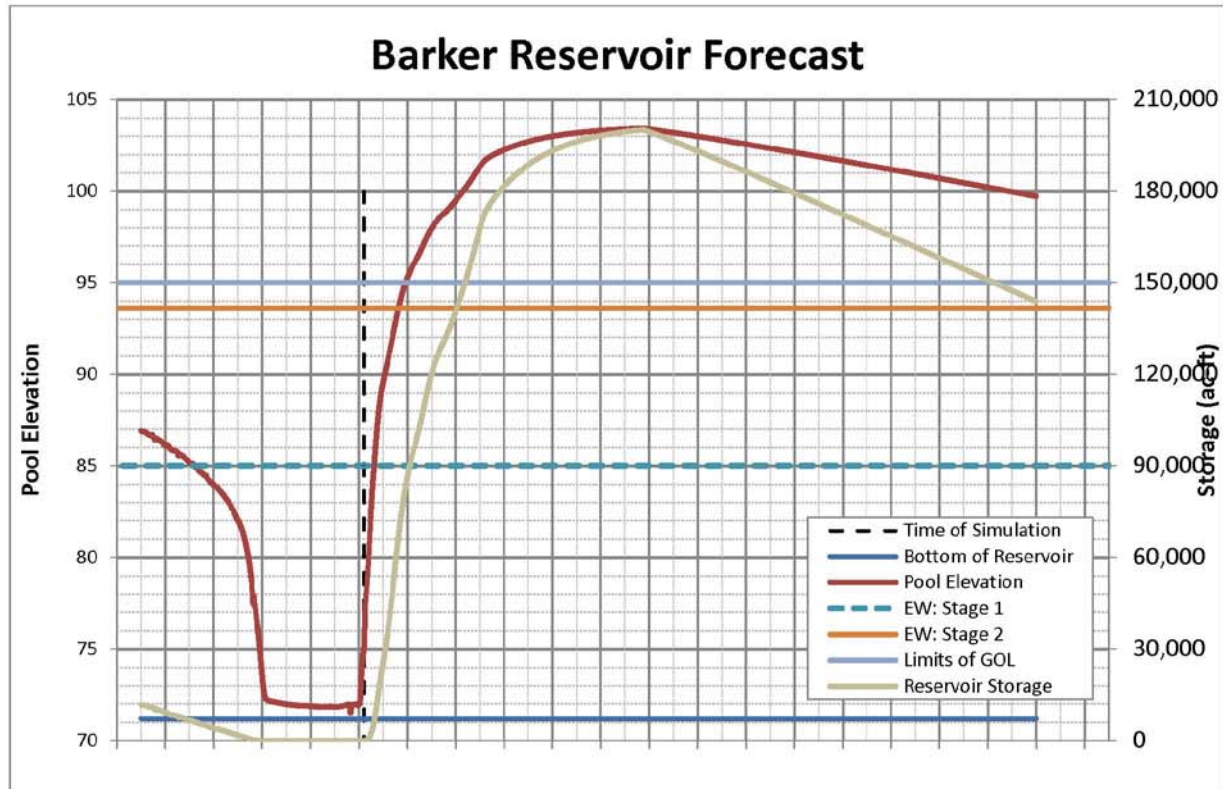


Addicks Reservoir Forecast



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Galveston District

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CWMS Forecast: 8/26/2017

The Addicks and Barker watersheds have received 4-6 inches across the watersheds in the last 24 hours. Gates were closed last night. Forecasted rainfall amounts are in flux. The 7-day accumulation assumed for this forecast is approximately 30-inches as received from the River Forecasting Center.

With rainfall continuing over the next 5+ days, the reservoirs are expected to exceed record pools. At this time, mandatory releases are expected to be necessary for surcharge operations at Addicks on Monday afternoon and at Barker on Thursday afternoon. Peak combined flows from the two reservoirs will be approximately 9,000 cfs.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

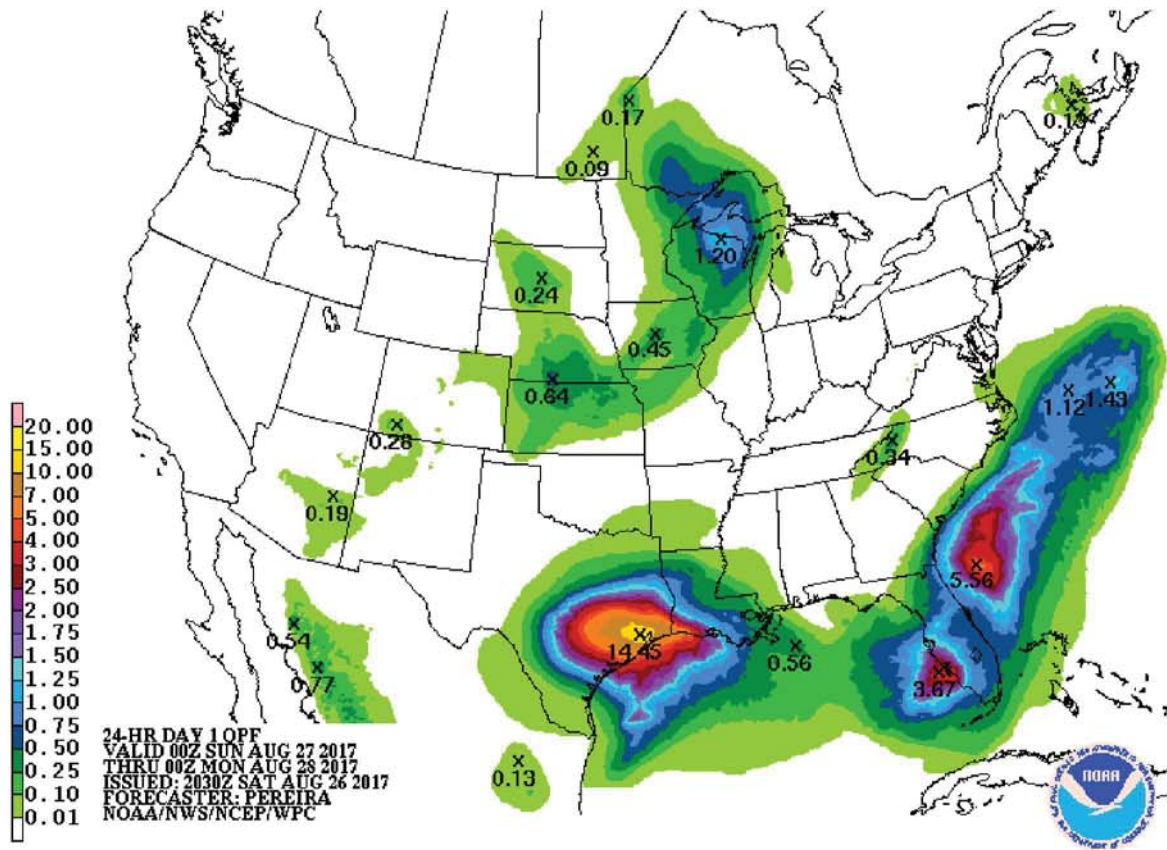
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 17:00 | 85 | 26 Aug 2017, 17:00 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 12:00 | 94.7 | 27 Aug 2017, 13:00 |
| Government Owned Land | 103 | 28 Aug 2017, 09:00 | 95 | 27 Aug 2017, 14:00 |
| first home flooded | 103.4 | 28 Aug 2017, 11:00 | 97.1 | 27 Aug 2017, 24:00 |
| End of Dam | 108 | 30 Aug 2017, 04:00 | 104 | not forecasted |
| Peak | 108.7 | 01 Sep 2017, 03:00 | 103.7 | 01 Sep 2017, 06:00 |

Forecast Information:

- Forecast Start Time: 8/26/2017 11:00
- Lookback Period: 10 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 80.58 ft (NAVD)
 - Barker: 80.58 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

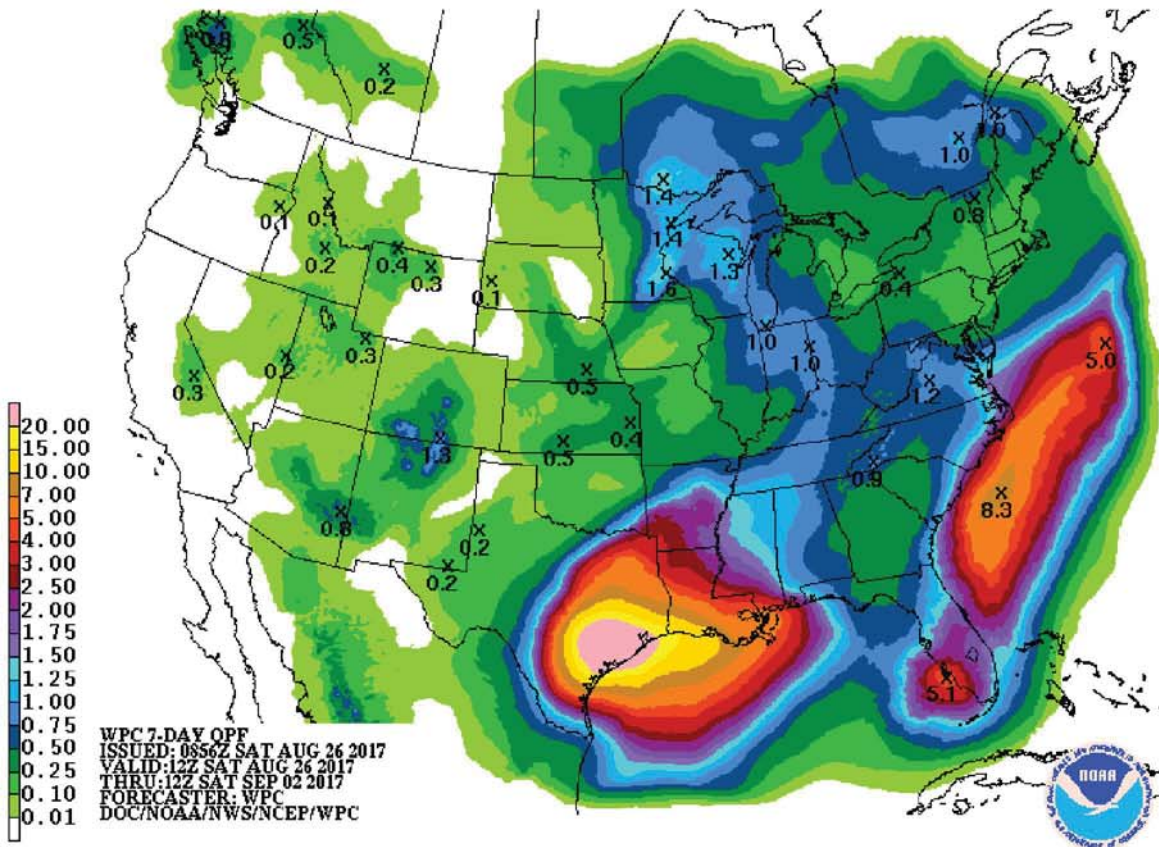
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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
26-Aug-17

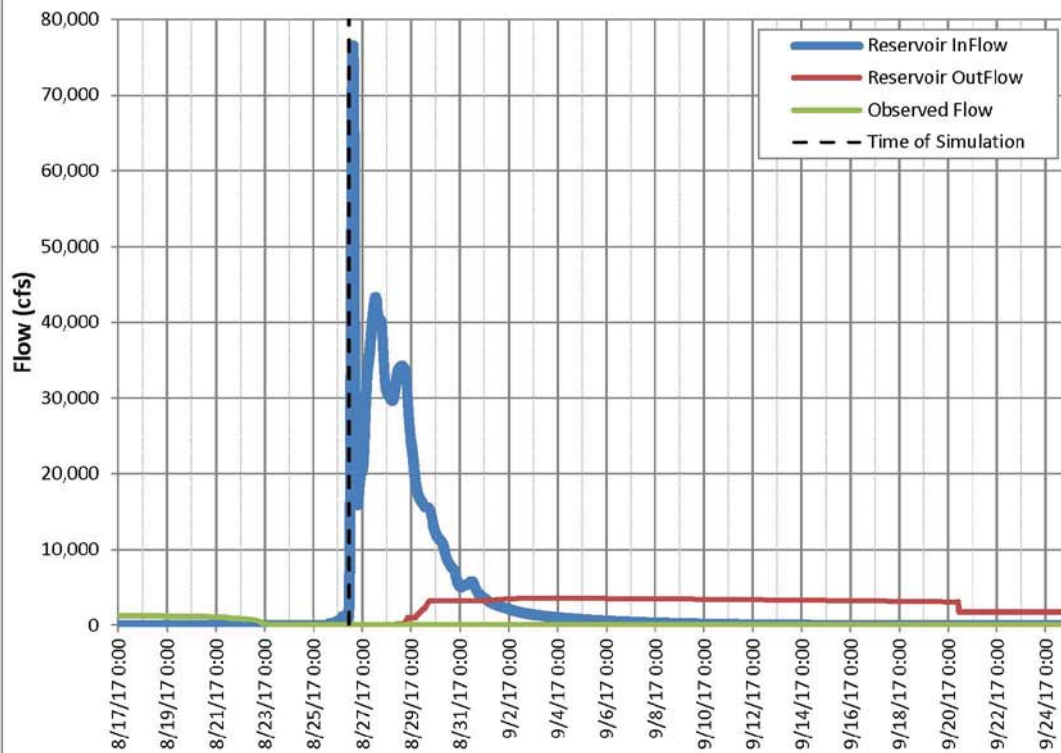
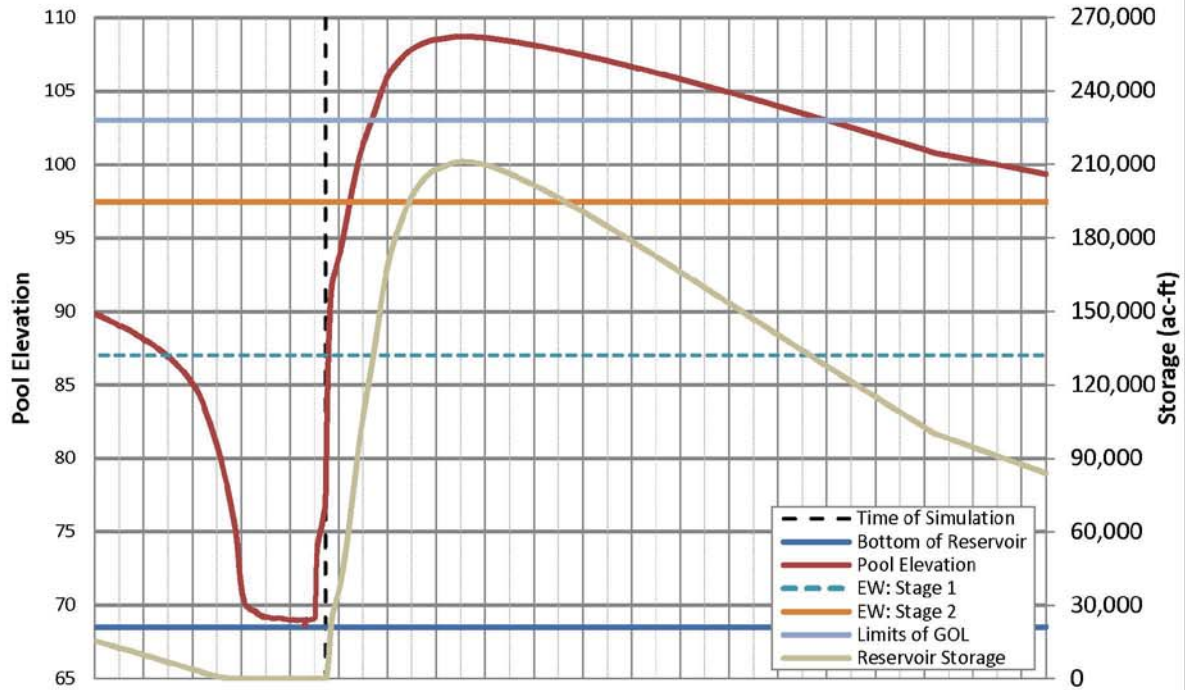
USACE005880

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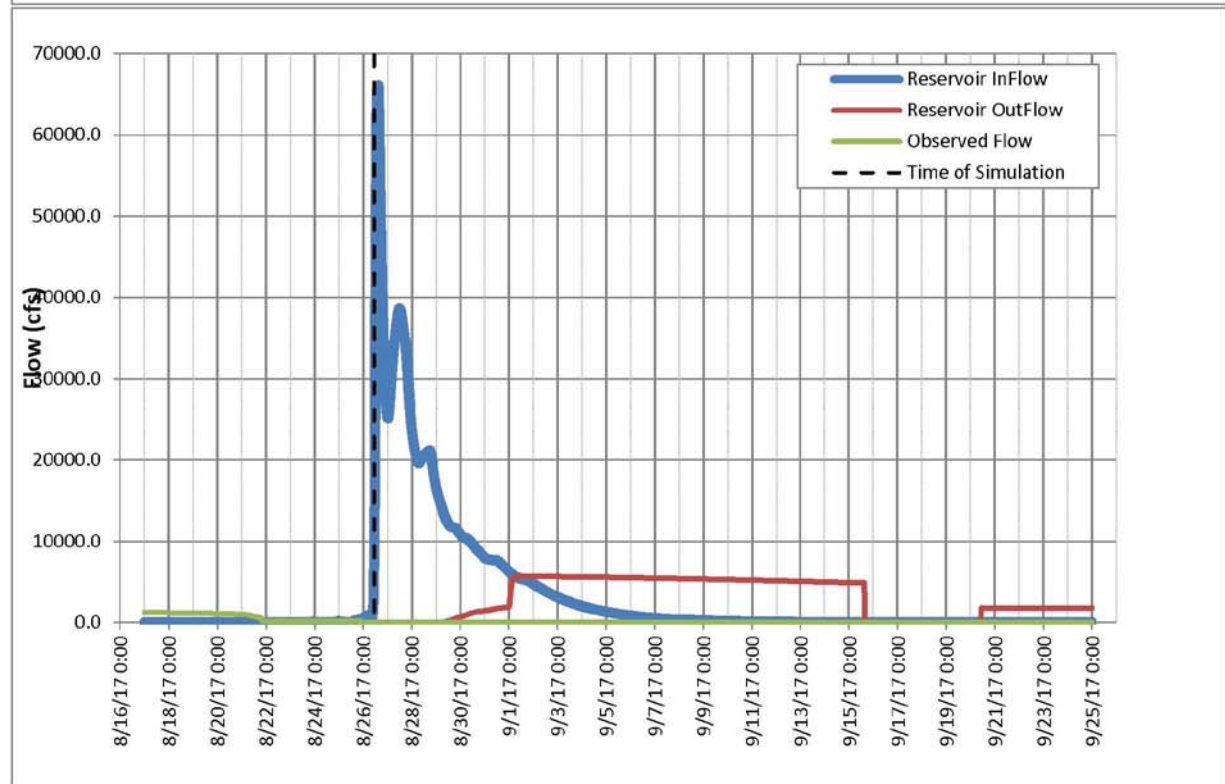
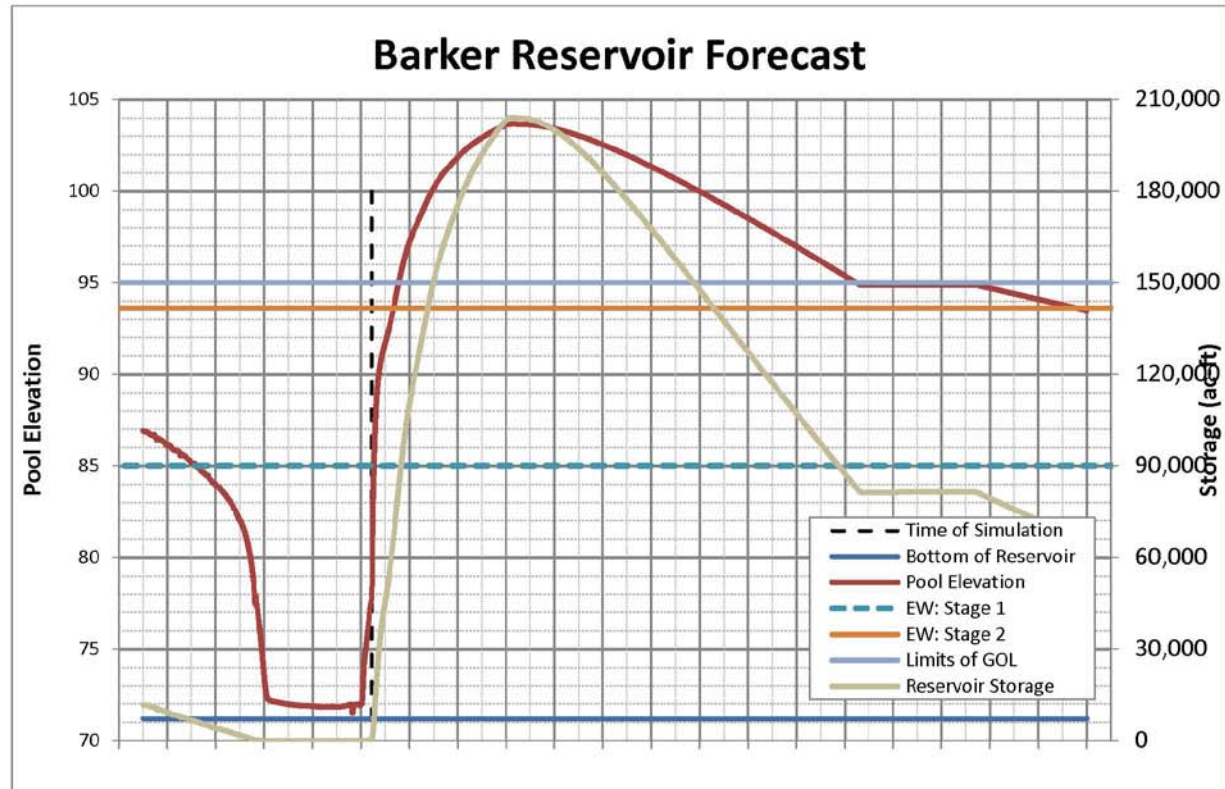


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 8/27/2017

The Addicks and Barker watersheds have received 10-18 inches across the watersheds in the last 48 hours. Gates are currently closed. Forecasted rainfall amounts are in flux. The 7-day accumulation assumed for this forecast is approximately 19-inches as received from the River Forecasting Center.

At this time, mandatory releases are expected to be necessary for surcharge operations at Addicks later tonight and at Barker on Wednesday. We are expected to have water around the north end of Addicks tomorrow night with peak flows of about 7000 cfs Thursday night. We are expected to have water around the ends of Barker Thursday, however the reservoir is forecasted to peak at 105, so the flows are minimal – less than 100 cfs

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

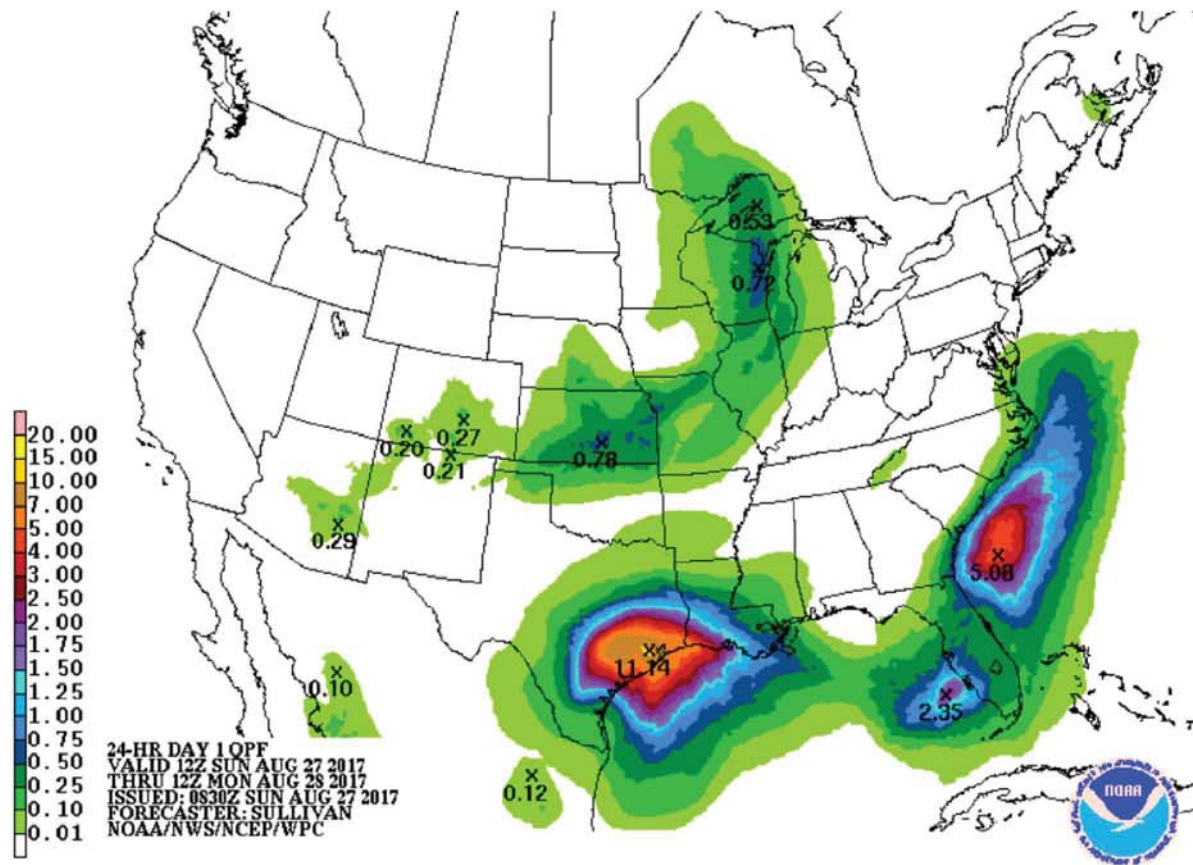
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 10:00 | 94.7 | 27 Aug 2017, 21:00 |
| Government Owned Land | 103 | 28 Aug 2017, 02:00 | 95 | 27 Aug 2017, 22:00 |
| first home flooded | 103.4 | 28 Aug 2017, 03:00 | 97.1 | 28 Aug 2017, 09:00 |
| Mandatory Releases begin | 103 | 28 Aug 2017, 02:00 | 102 | 30 Aug 2017, 11:00 |
| End of Dam | 108 | 28 Aug 2017, 23:00 | 104 | 31 Aug 2017, 19:00 |
| Peak | 110.6 | 31 Aug 2017, 19:00 | 105 | 03 Sep 2017, 10:00 |

Forecast Information:

- Forecast Start Time: 8/27/2017 5:00
- Lookback Period: 11 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 94.03 ft (NAVD)
 - Barker: 88.80 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

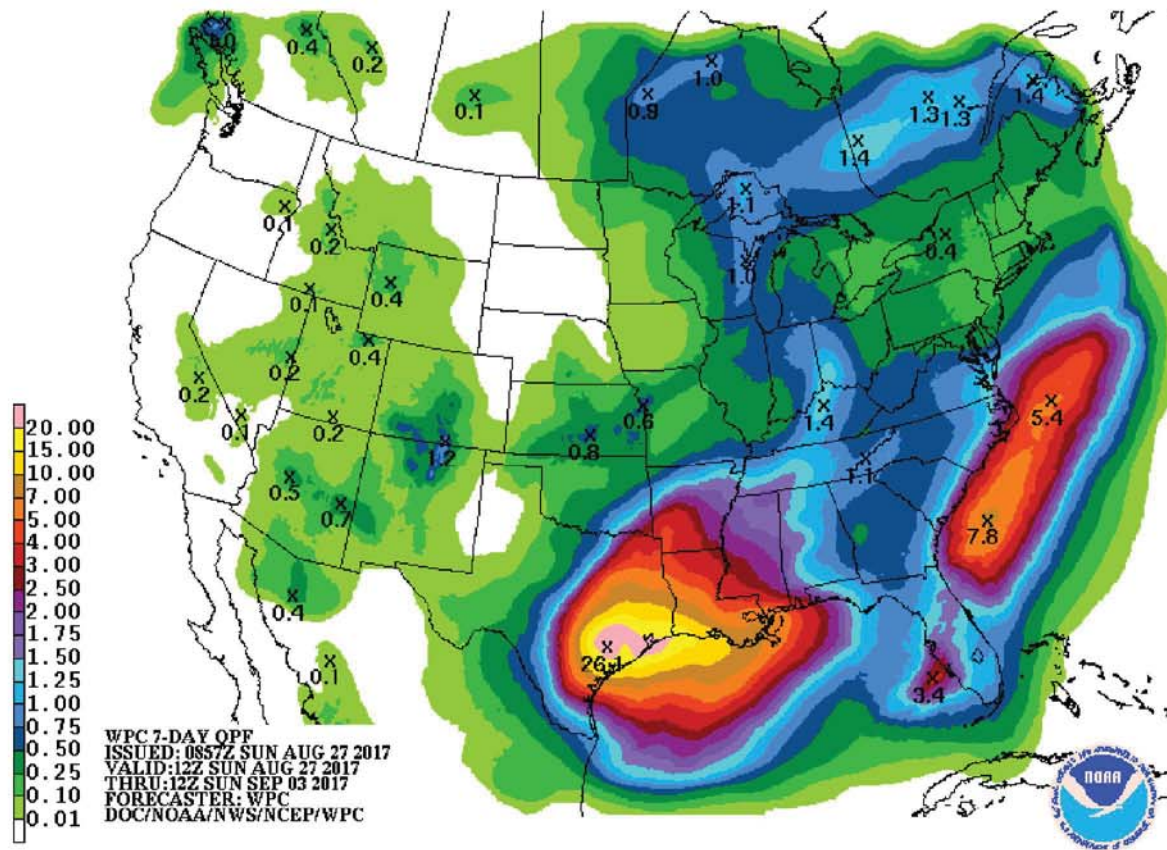
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24-hour QPF

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M3ODXMGK

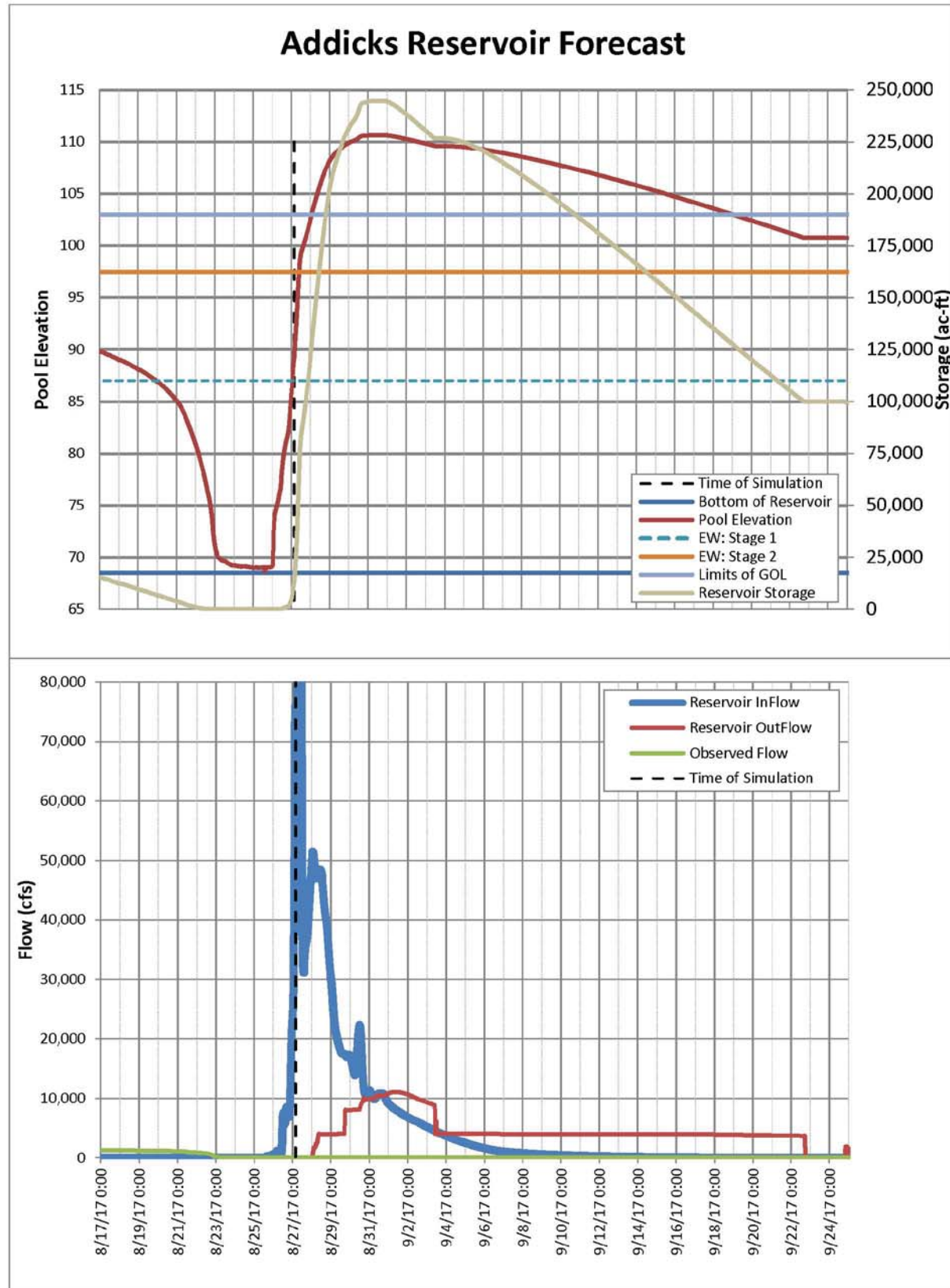
Page 3 of 5

Forecasted on:
27-Aug-17

USACE005885

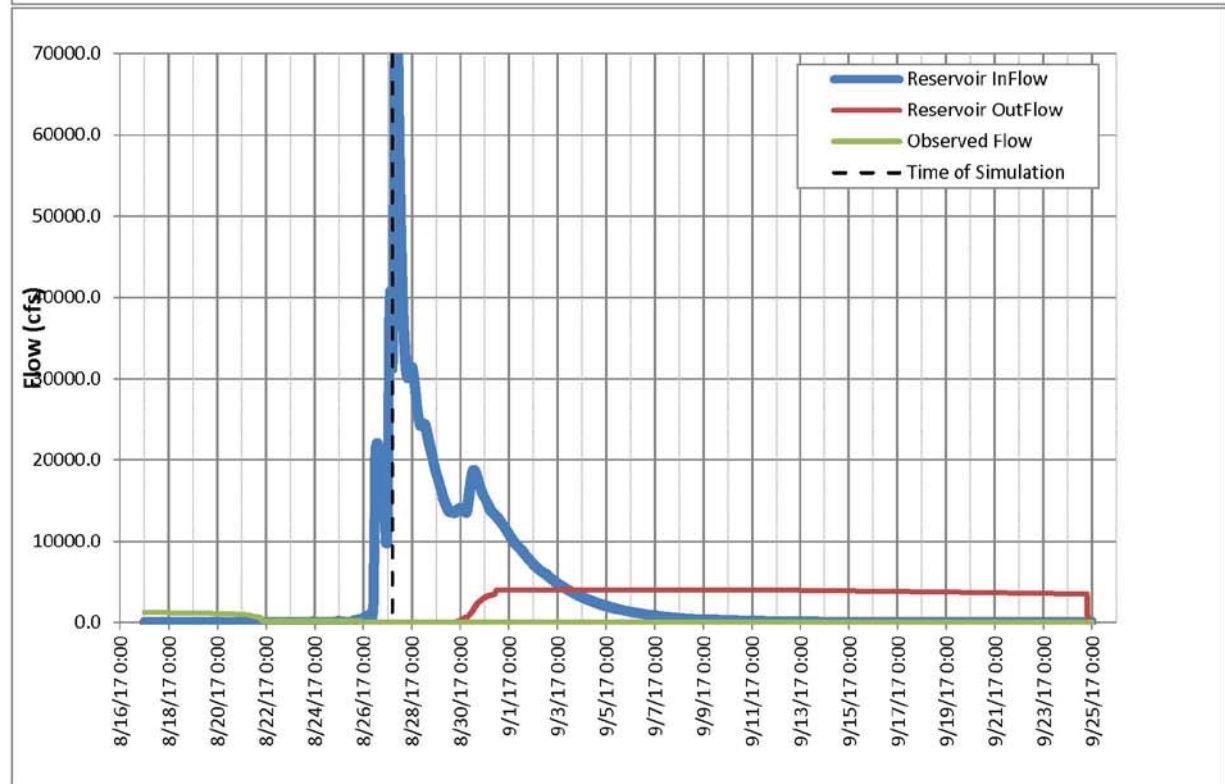
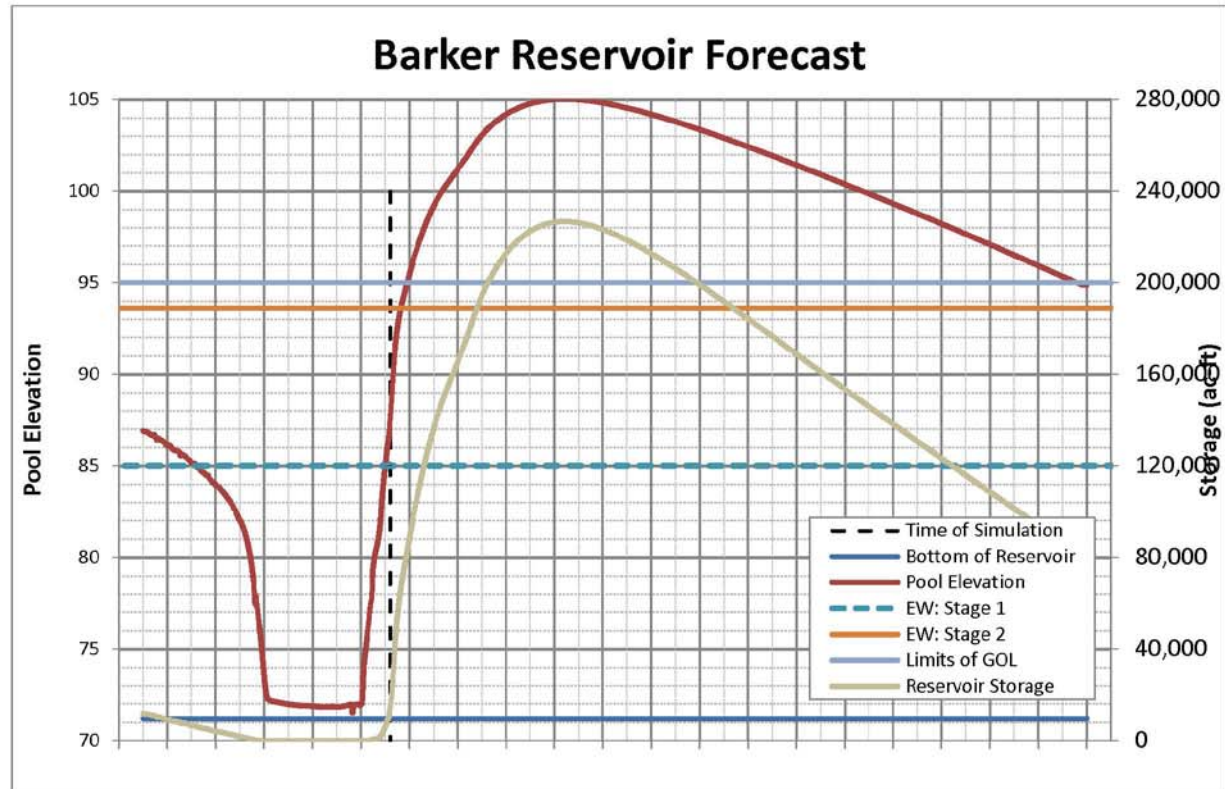
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CWMS Forecast: 8/27/2017

The Addicks and Barker watersheds have received 10-18 inches across the watersheds in the last 48 hours. Gates are currently closed. Forecasted rainfall amounts are in flux. The 7-day accumulation assumed for this forecast is approximately 30-inches as received from the River Forecasting Center.

At this time, mandatory releases are expected to be necessary for surcharge operations at Addicks later tonight and at Barker on Wednesday. We are expected to have water around the north end of Addicks tomorrow night with peak flows of about 6000 cfs Friday morning. We are expected to have water around the ends of Barker Thursday, however the reservoir is forecasted to peak at 104.3, so the flows are minimal – less than 100 cfs

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

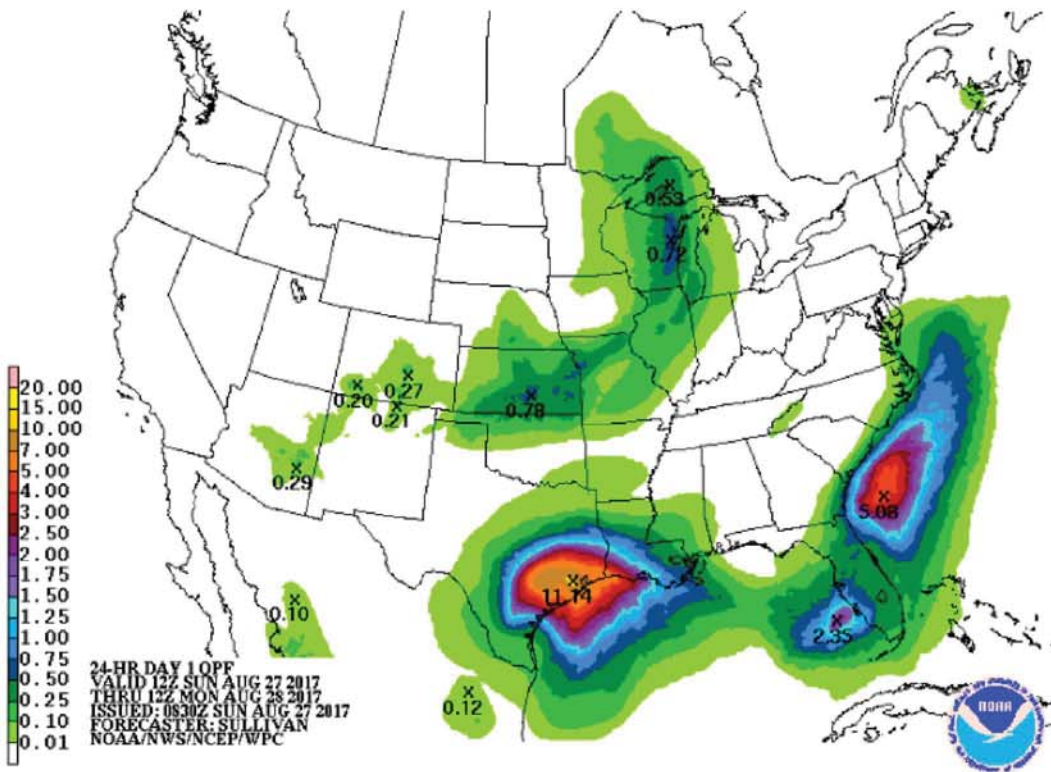
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 14:00 | 94.7 | 28 Aug 2017, 01:00 |
| Government Owned Land | 103 | 28 Aug 2017, 03:00 | 95 | 28 Aug 2017, 02:00 |
| first home flooded | 103.4 | 28 Aug 2017, 04:00 | 97.1 | 28 Aug 2017, 14:00 |
| Mandatory Releases begin | | 28 Aug 2017, 02:00 | | 30 Aug 2017, 11:00 |
| End of Dam | 108 | 29 Aug 2017, 02:00 | 104 | 01 Sep 2017, 17:00 |
| Peak | 110.5 | 31 Aug 2017, 18:00 | 104.3 | 03 Sep 2017, 06:00 |

Forecast Information:

- Forecast Start Time: 8/27/2017 5:00
- Lookback Period: 11 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 94.03 ft (NAVD)
 - Barker: 88.80 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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24-hour QPF

Forecasted by:
M30DXMGK

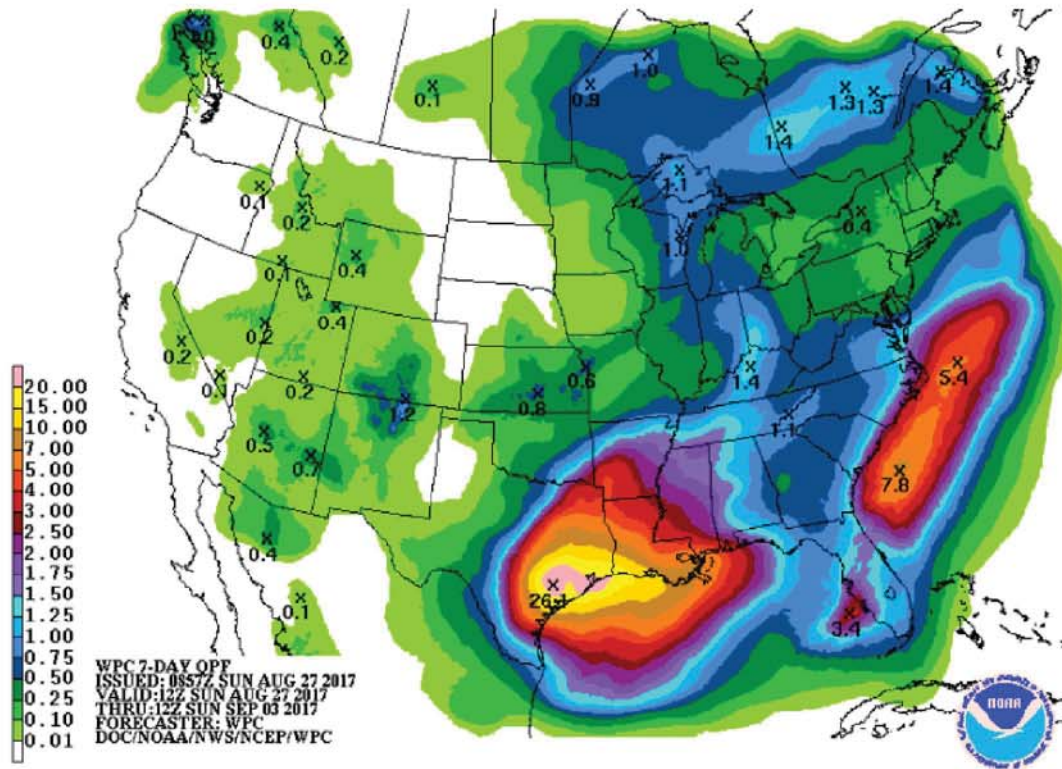
Page 2 of 5

Forecasted on:
27-Aug-17

USACE005889

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Galveston District

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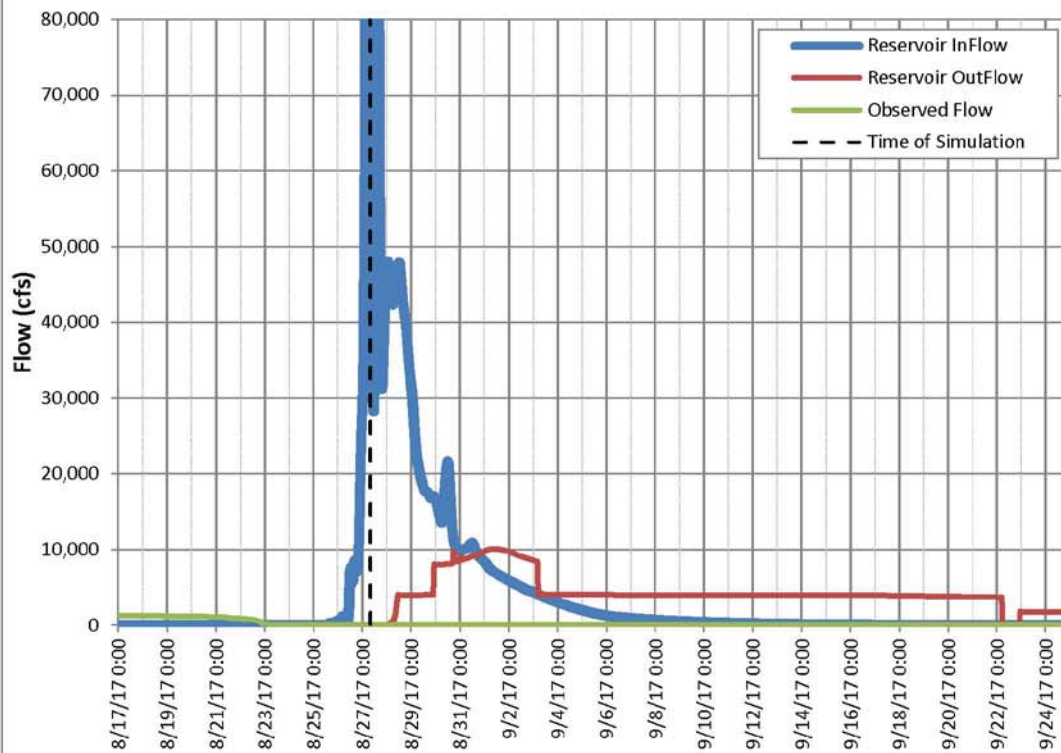
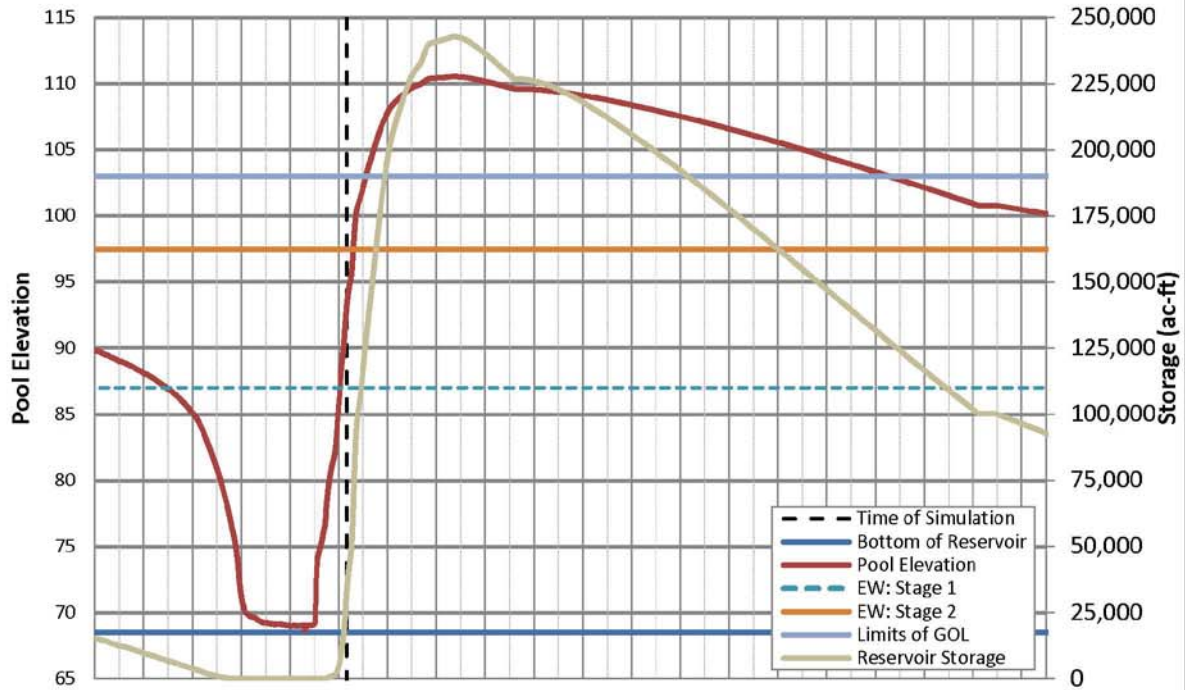
7-day QPF

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Galveston District

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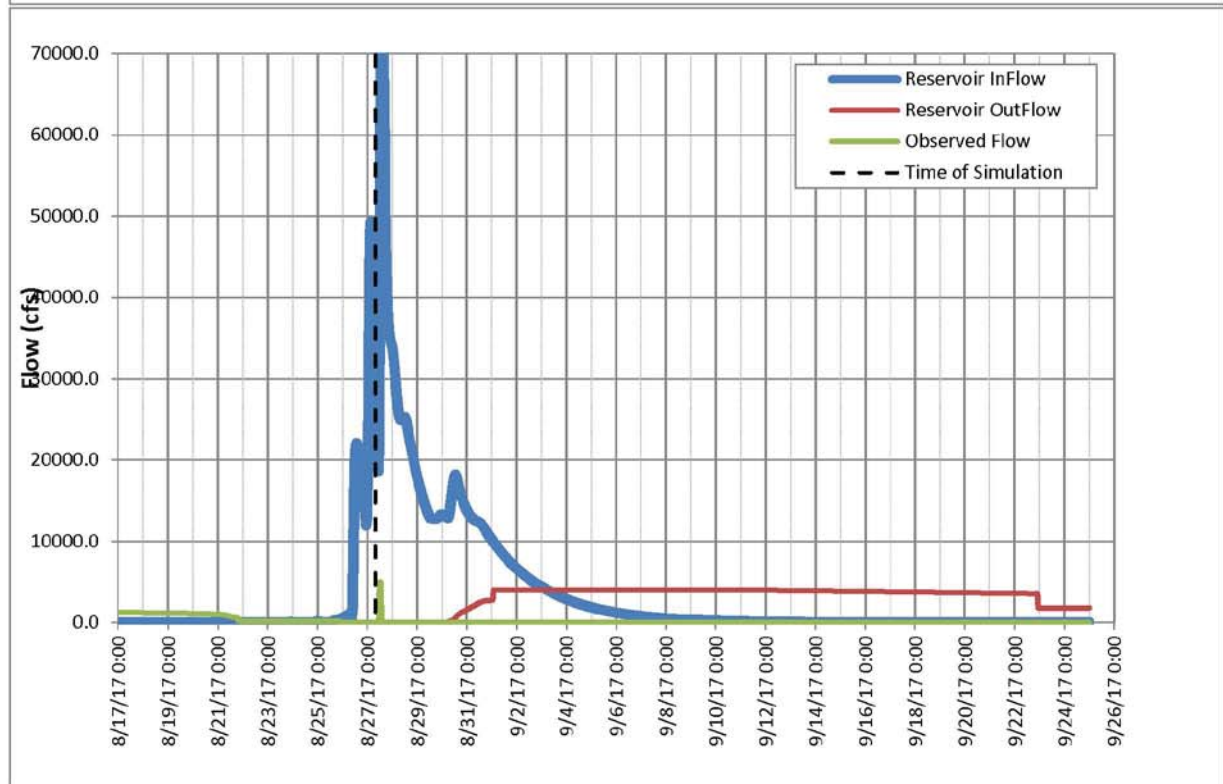
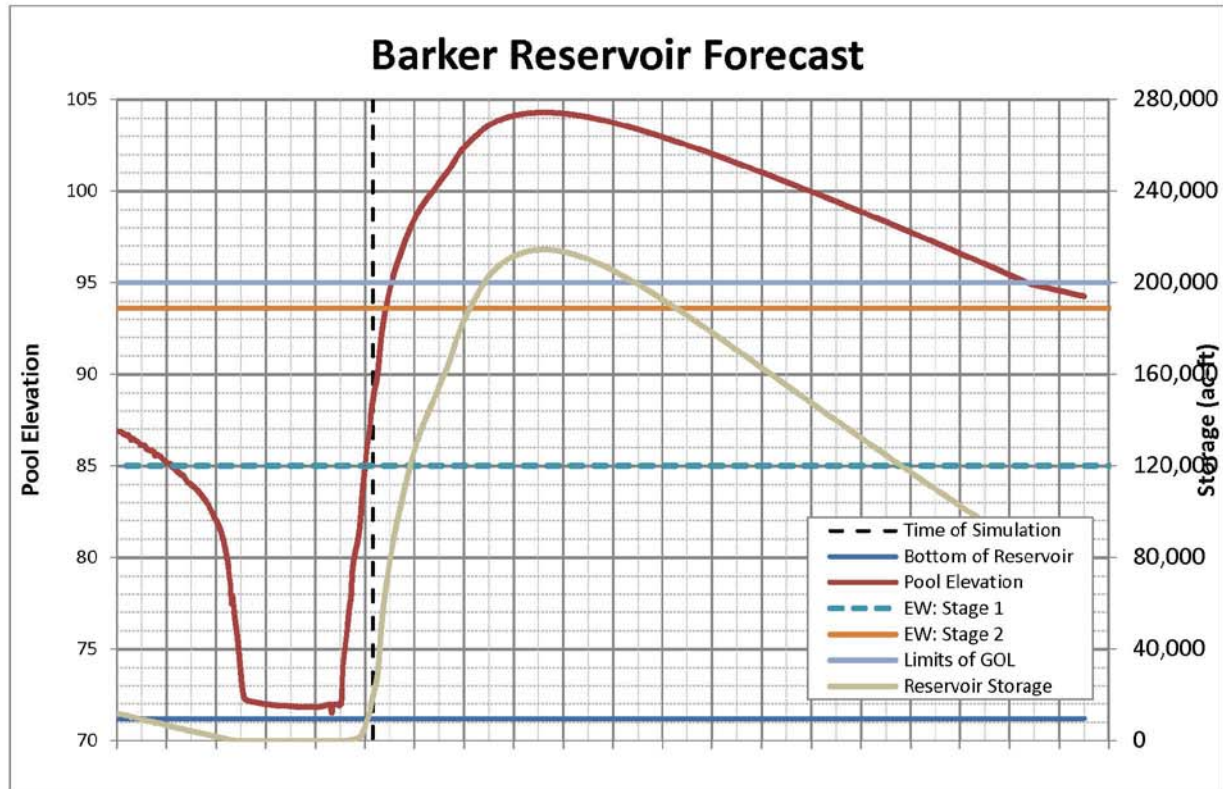


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 8/28/2017

The Addicks and Barker watersheds have received 25-28 inches across the watersheds since the beginning of this event. Gates were closed at the time of forecast. Forecasted rainfall amounts are in flux. The 7-day accumulation assumed for this forecast is 25 inches as received from the River Forecasting Center.

At this time, releases have begun at Addicks and Barker tonight due to the speed at which the pools have been rising. We are expected to have water around the north end of Addicks later tonight with peak flows of about 22000 cfs Friday morning. At this time, flows are not expected to reach the ends of Barker Dam.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

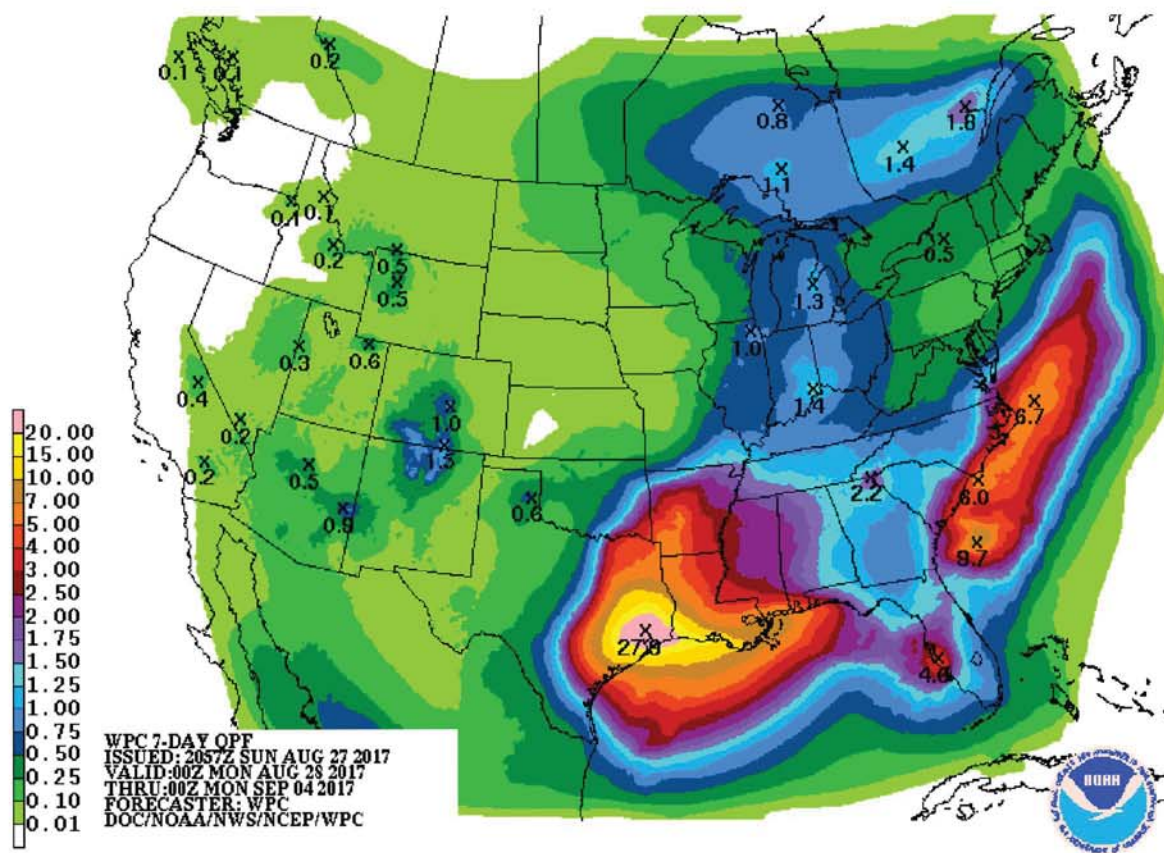
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 11:30 | 94.7 | 27 Aug 2017, 22:00 |
| Government Owned Land | 103 | 28 Aug 2017, 03:00 | 95 | 27 Aug 2017, 2245 |
| first home flooded | 103.4 | 28 Aug 2017, 04:00 | 97.1 | 28 Aug 2017, 13:00 |
| Mandatory Releases begin | | 28 Aug 2017, 01:00 | | 27 Aug 2017, 24:00 |
| End of Dam | 108 | 28 Aug 2017, 19:00 | 104 | NA |
| Peak | 112.24 | 29 Aug 2017, 22:00 | 103.8 | 31 Aug 2017, 07:00 |

Forecast Information:

- Forecast Start Time: 8/27/2017 23:00
- Lookback Period: 11 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 94.03 ft (NAVD)
 - Barker: 88.80 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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24-hour QPF

Forecasted by:
M30DXMGK

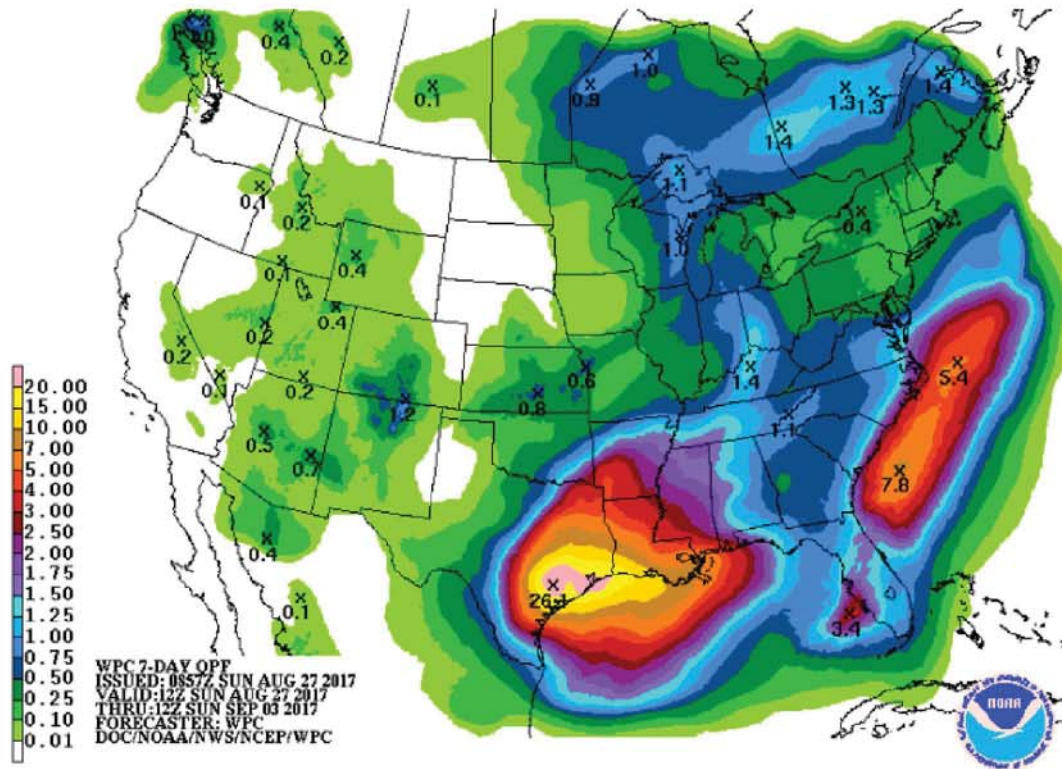
Page 2 of 5

Forecasted on:
28-Aug-17

USACE005894

U.S. Army Corps of Engineers
Galveston District

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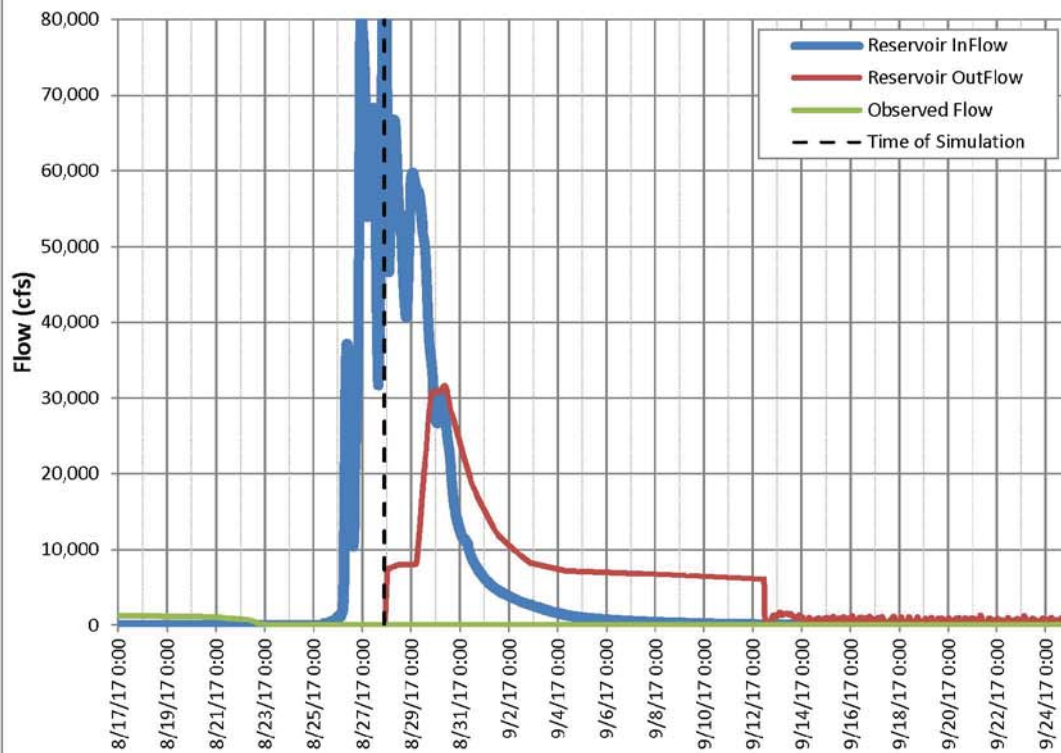
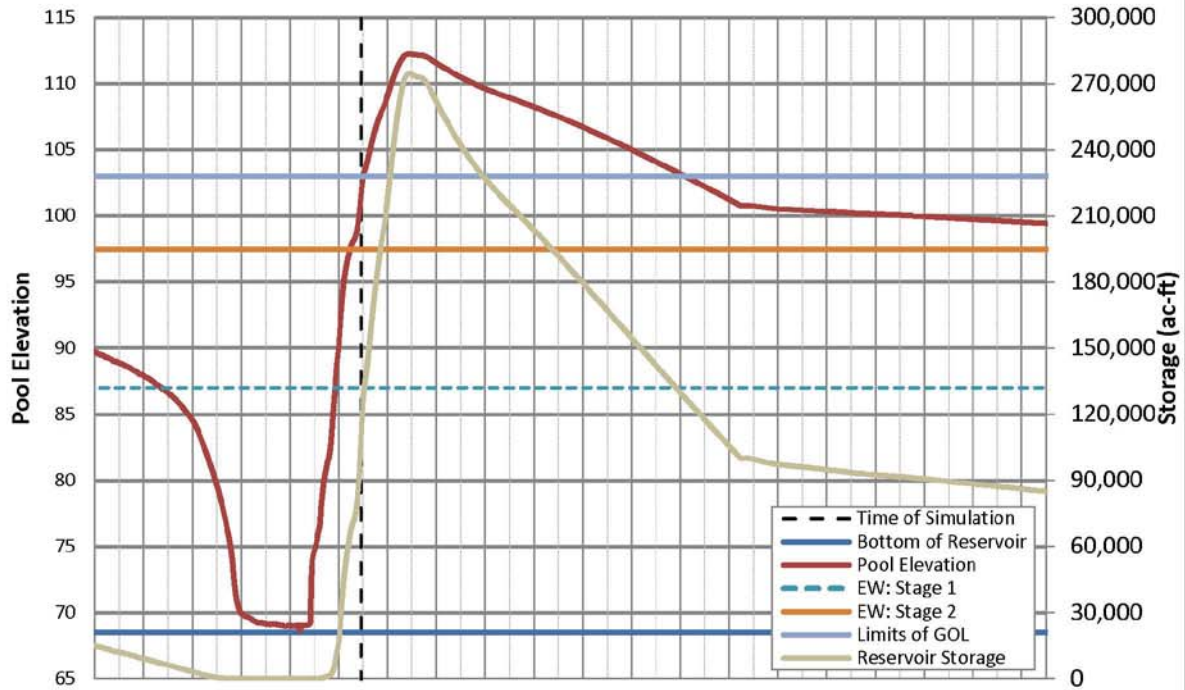
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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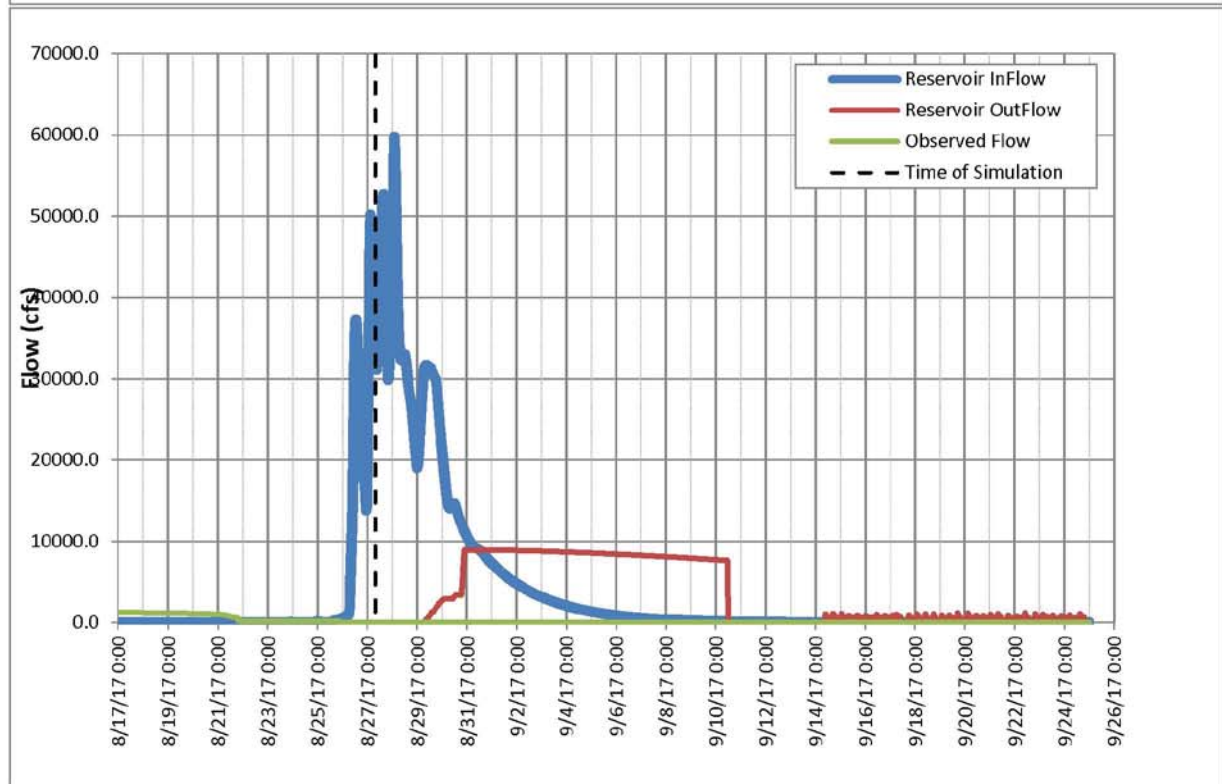
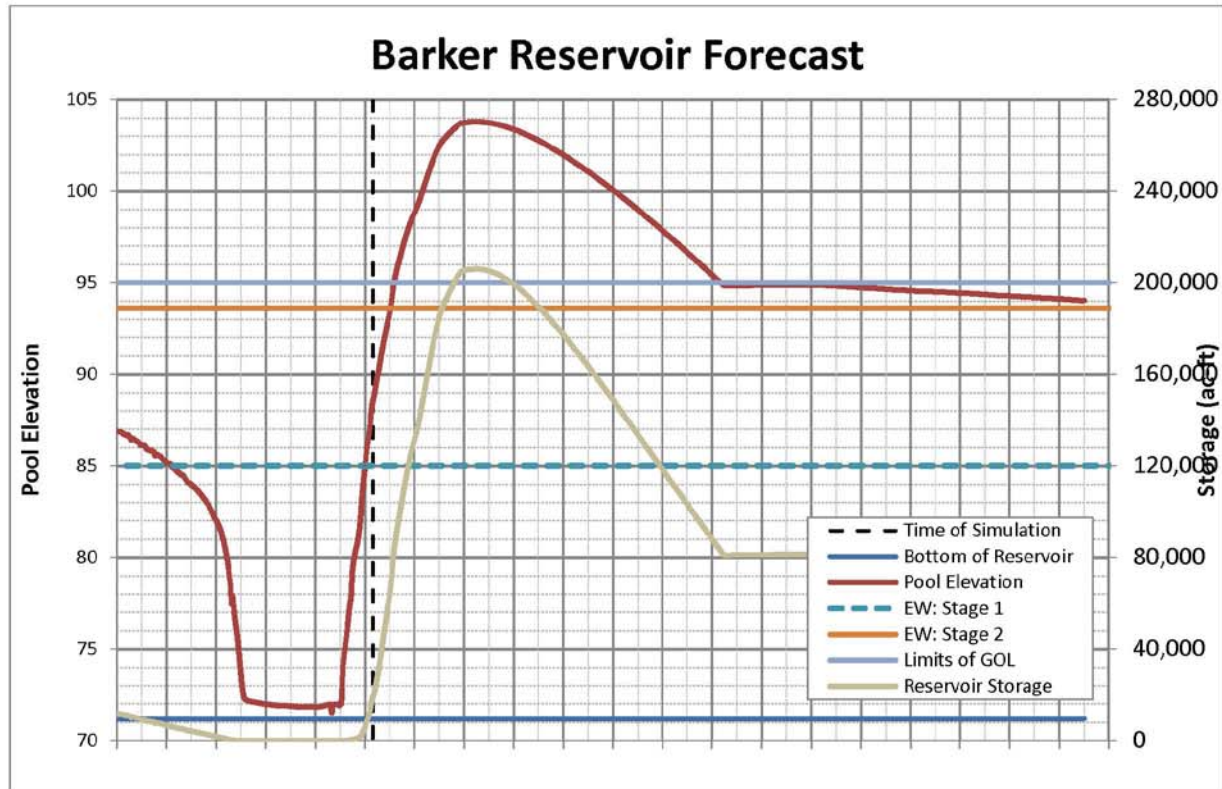


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 8/29/2017

The Addicks and Barker watersheds have received 30-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began yesterday. The 4-day accumulation assumed for this forecast is 9 inches as received from the River Forecasting Center.

At this time, Addicks is releasing approximately 2600 cfs and Barker is releasing approximately 3100 cfs. Discharges will be increased at both reservoirs so that each reservoir will be releasing approximately 4000 cfs later today. The pool is expected to continue rising with water eventually going over the uncontrolled spillways at the ends of the dams. Flows around the north end of Addicks will peak at about 4500 cfs. Flows around the north end of Barker will be about 200 cfs and <100 cfs around the south end of Barker.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

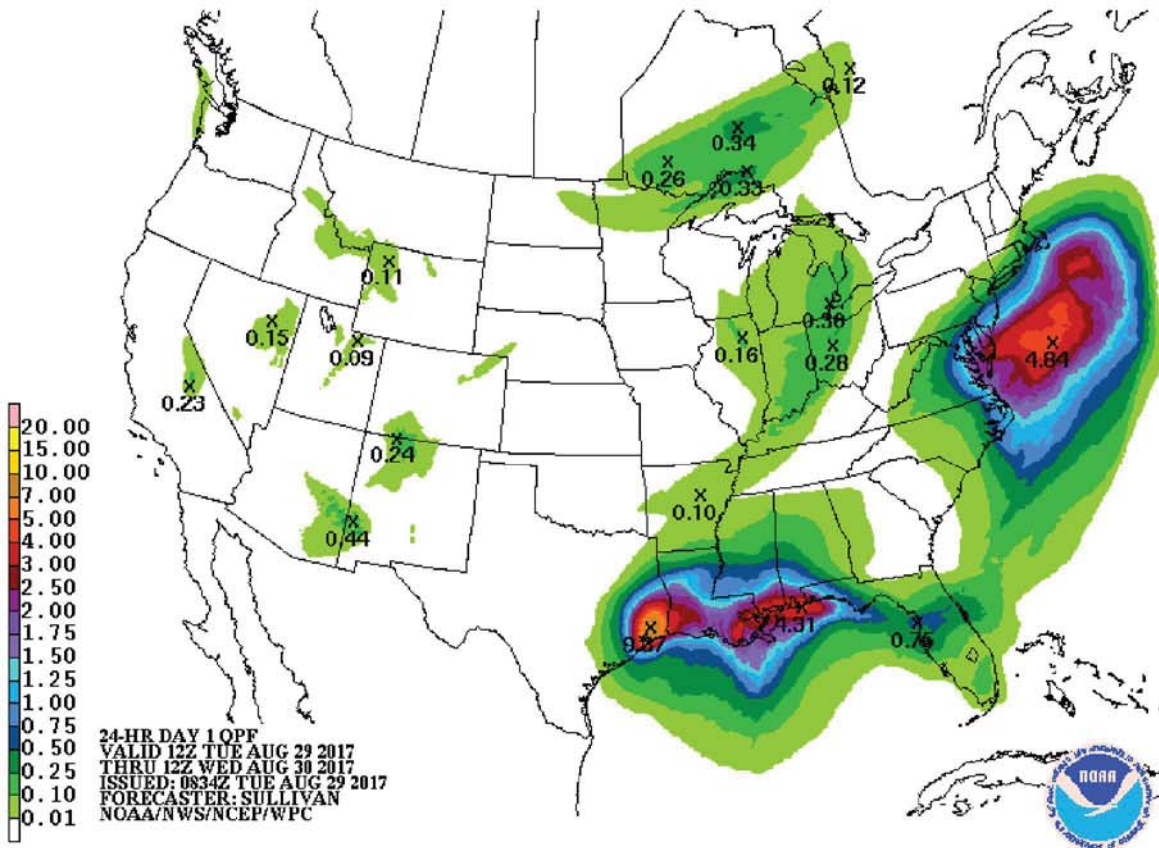
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 11:30 | 94.7 | 27 Aug 2017, 22:00 |
| Government Owned Land | 103 | 28 Aug 2017, 07:15 | 95 | 27 Aug 2017, 22:45 |
| first home flooded | 103.4 | 28 Aug 2017, 09:15 | 97.1 | 28 Aug 2017, 06:00 |
| Mandatory Releases begin | | 28 Aug 2017, 01:00 | | 28 Aug 2017, 01:00 |
| End of Dam | 108 | 29 Aug 2017, 10:00 | 104 | 31 Aug 2017, 22:00 |
| Peak | 110.4 | 31 Aug 2017, 12:00 | 104.4 | 2 Sep 2017, 15:00 |

Forecast Information:

- Forecast Start Time: 8/29/2017 00:00
- Lookback Period: 5 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Manual QPF
- Starting reservoir levels
 - Addicks: 106.65 ft (NAVD)
 - Barker: 100.3 ft (NAVD) - estimated
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

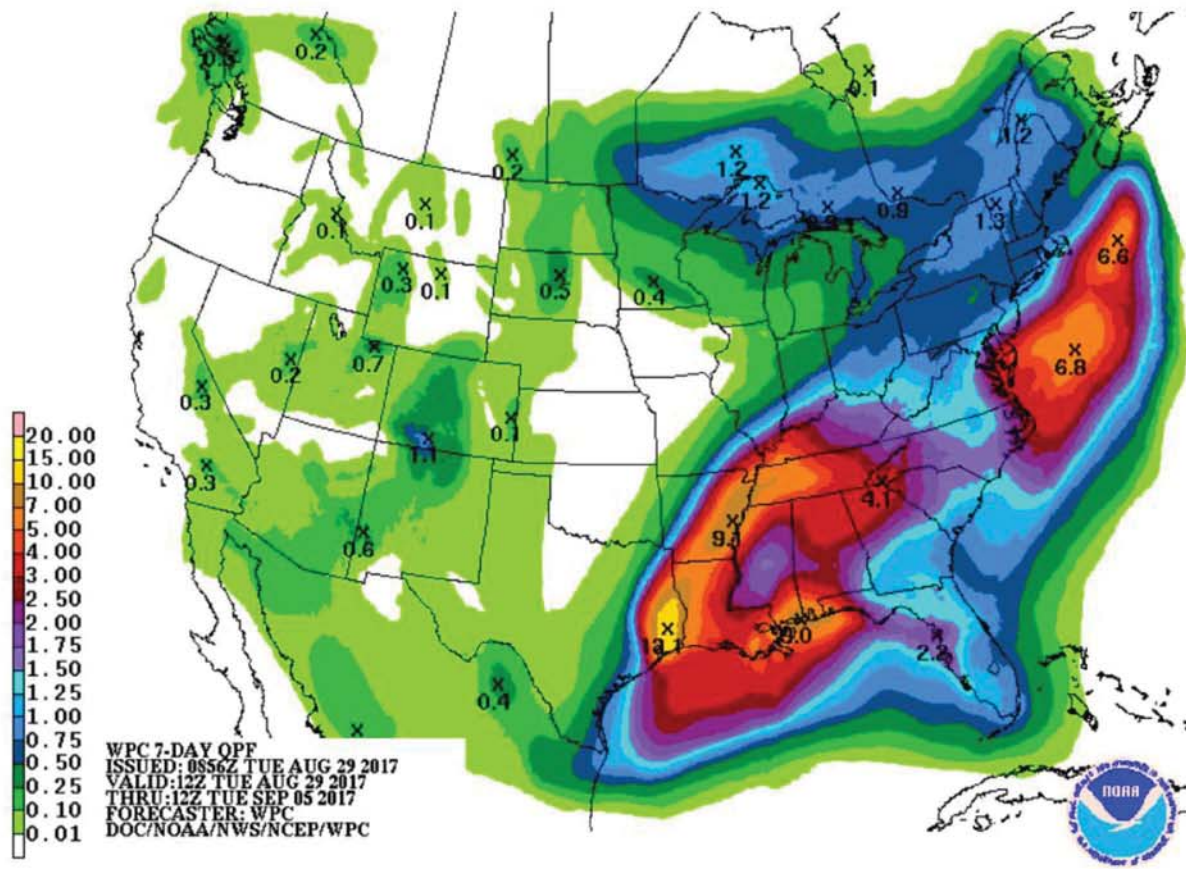
DRAFT



24-hour QPF

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 3 of 5

Forecasted on:
29-Aug-17

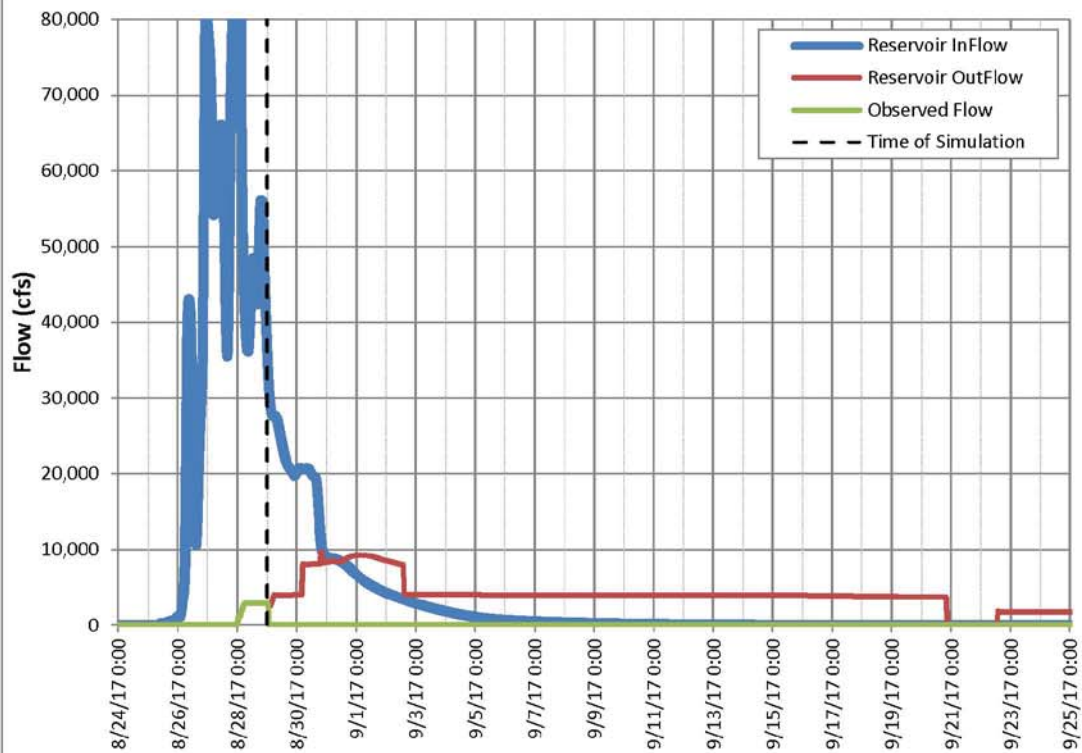
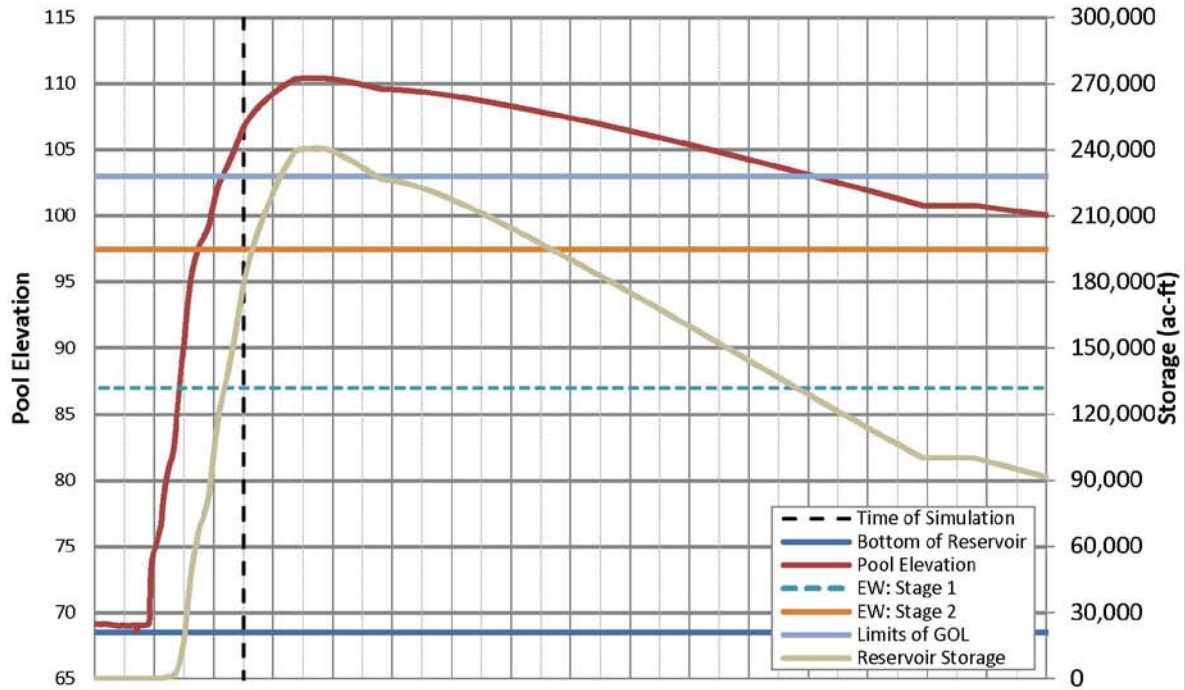
USACE005900

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

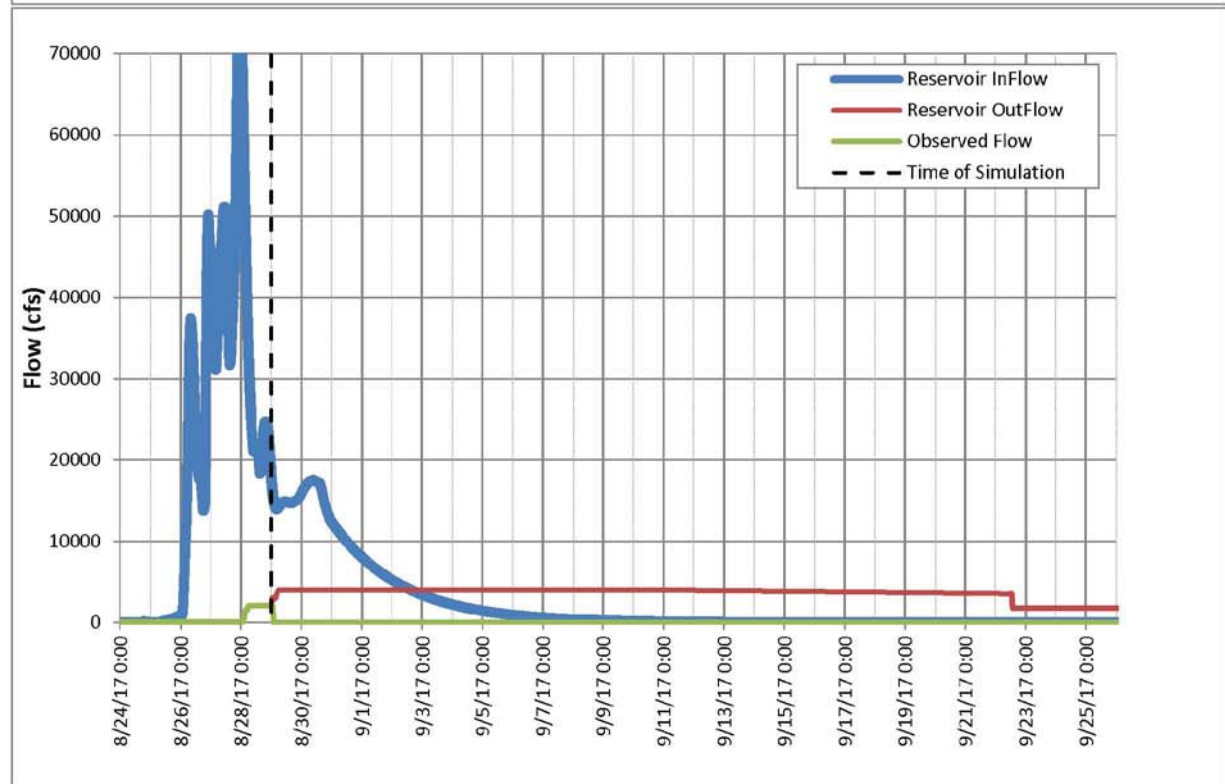
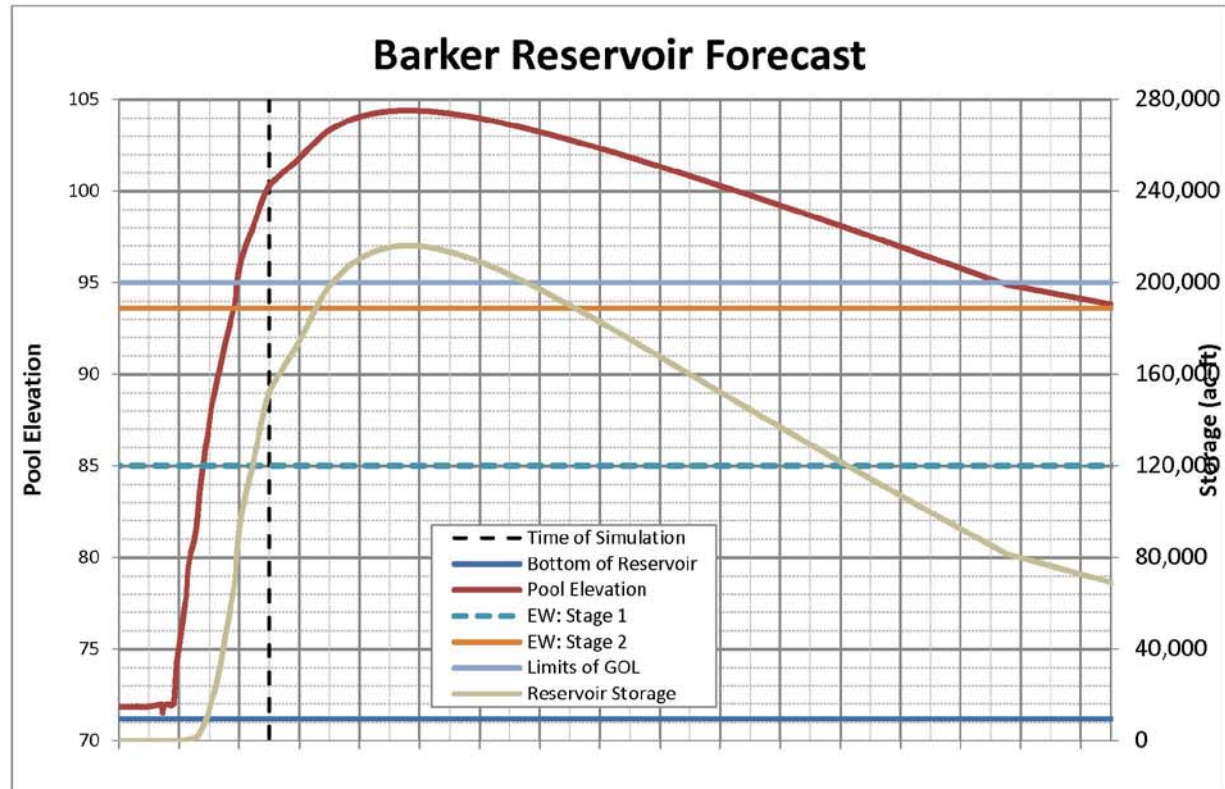
Page 4 of 5

Forecasted on:
29-Aug-17

USACE005901

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 8/30/2017

The Addicks and Barker watersheds have received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 2 days ago. The 7-day accumulation assumed for this forecast is less than one inch.

At this time, Addicks is releasing approximately 7500 cfs and Barker is releasing approximately 6300 cfs. Flows around the north end of Addicks began yesterday morning. Due to the increased releases from the dam yesterday and less rain falling than was forecasted, Addicks is expected to peak today before the emergency spillway is activated. The Barker Reservoir pool is not expected to flank the ends of the dam.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

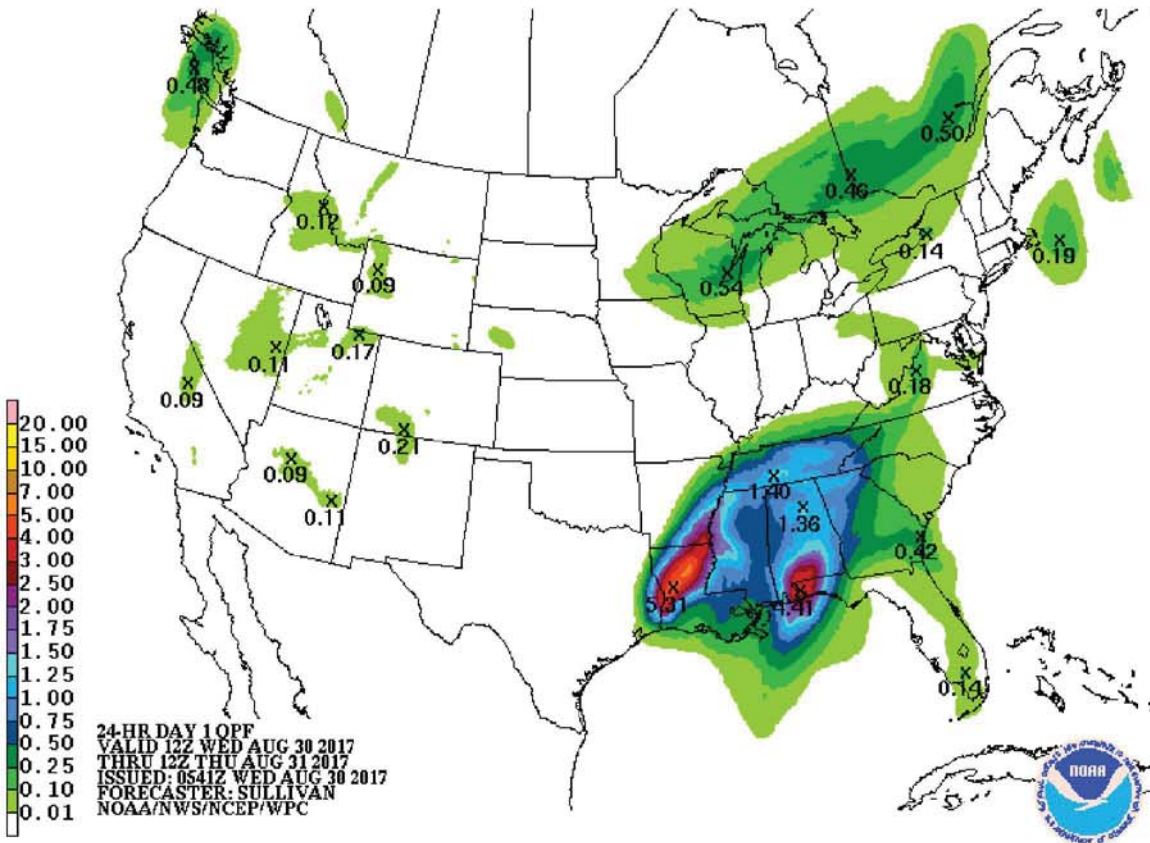
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 11:30 | 94.7 | 27 Aug 2017, 22:00 |
| Government Owned Land | 103 | 28 Aug 2017, 07:15 | 95 | 27 Aug 2017, 22:45 |
| first home flooded | 103.4 | 28 Aug 2017, 09:15 | 97.1 | 28 Aug 2017, 06:00 |
| Mandatory Releases begin | | 28 Aug 2017, 01:00 | | 28 Aug 2017, 01:00 |
| End of Dam | 108 | 29 Aug 2017, 07:15 | 104 | N/A |
| Peak | 109.0 | 30 Aug 2017, 06:00 | 101.8 | 31 Aug 2017, 00:00 |

Forecast Information:

- Forecast Start Time: 8/29/2017 23:00
- Lookback Period: 5 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Manual QPF
- Starting reservoir levels
 - Addicks: 108.98 ft (NAVD) (08/30/2017 03:00 elevation 109.03)
 - Barker: 101.53 ft (NAVD) (08/30/2017 03:00 elevation 101.55)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

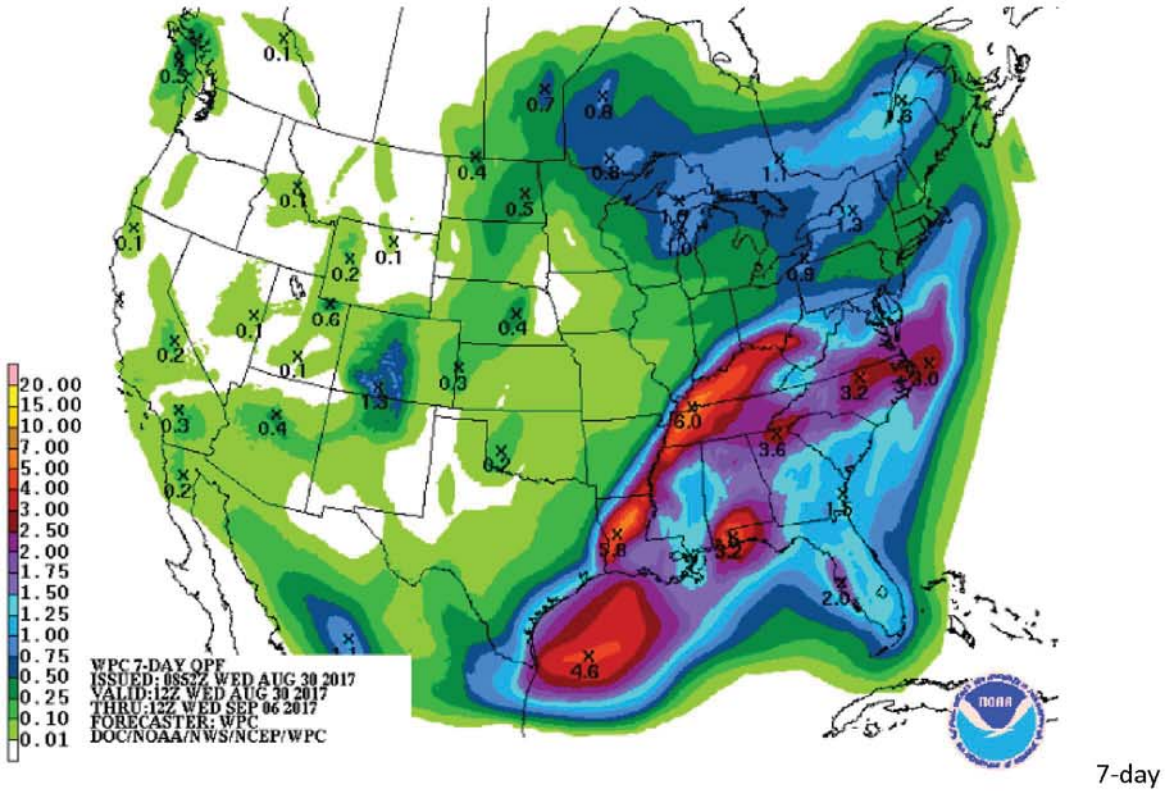
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24-hour QPF

U.S. Army Corps of Engineers
Galveston District

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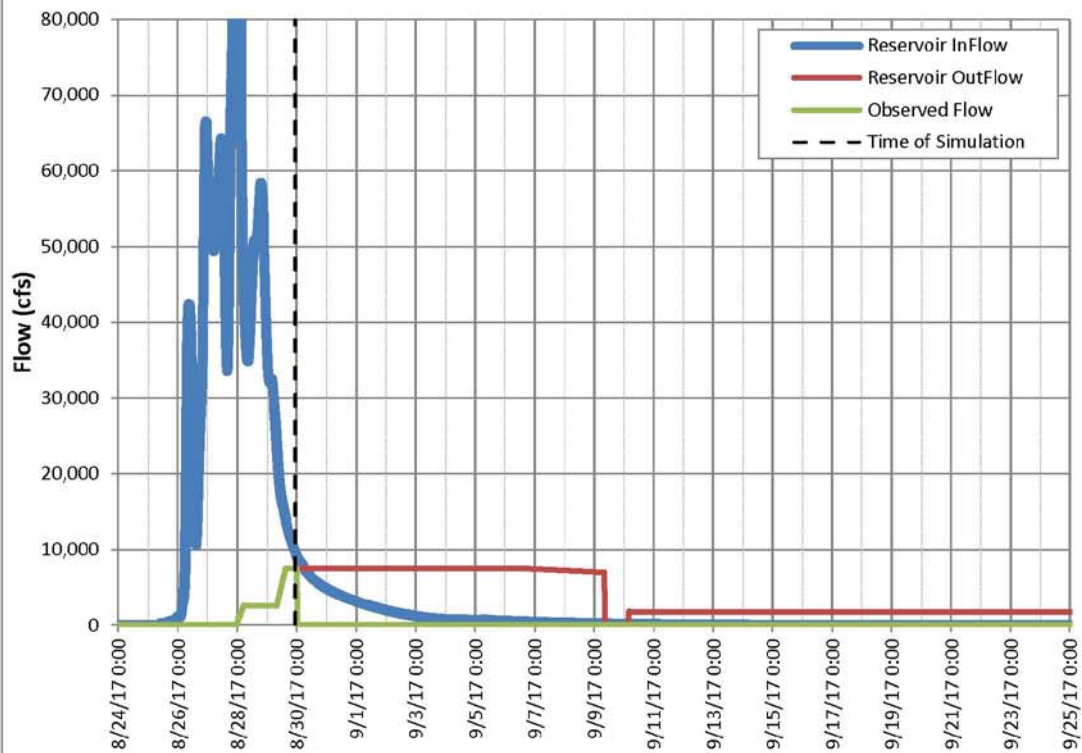
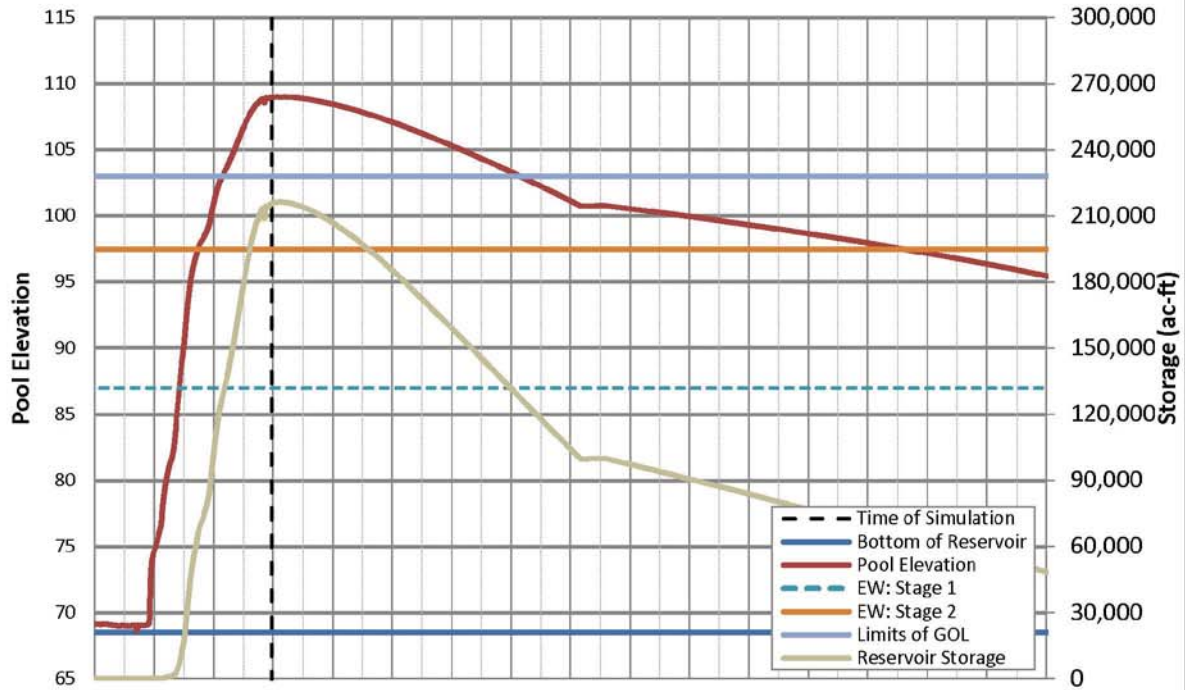
QPF

U.S. Army Corps of Engineers
Galveston District

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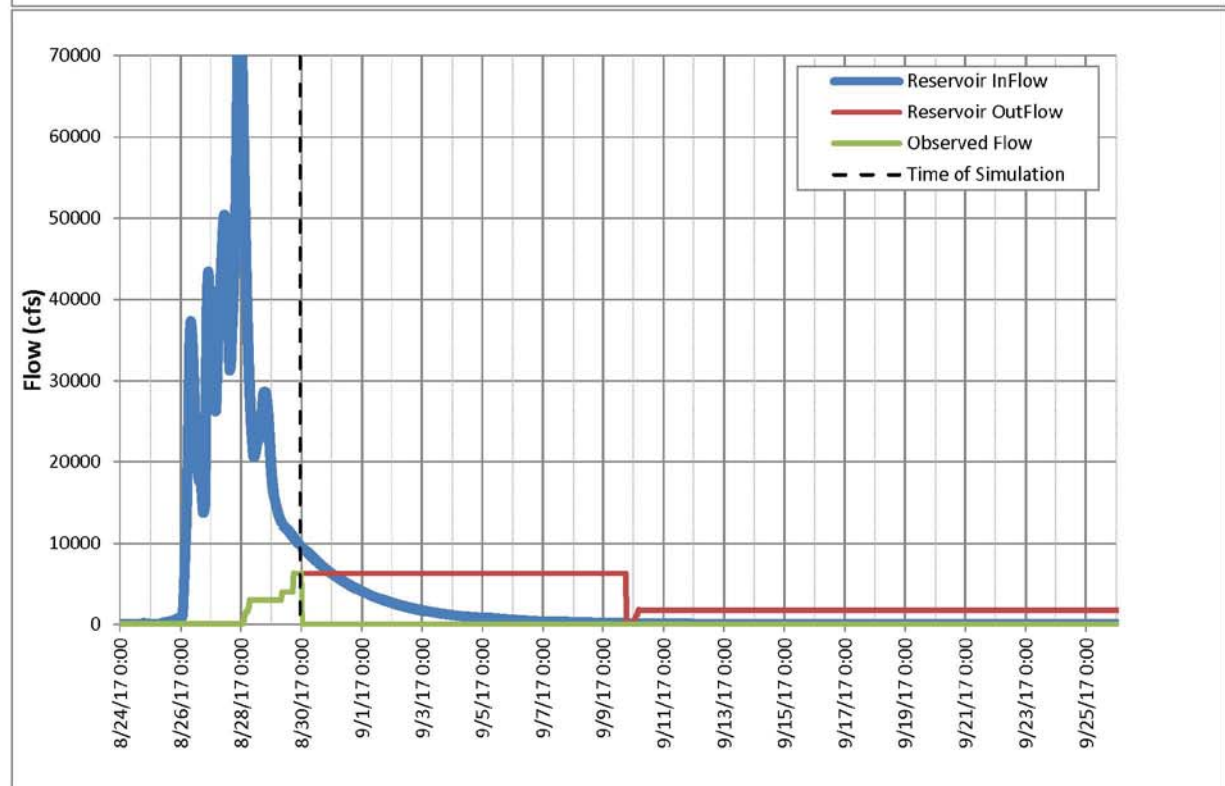
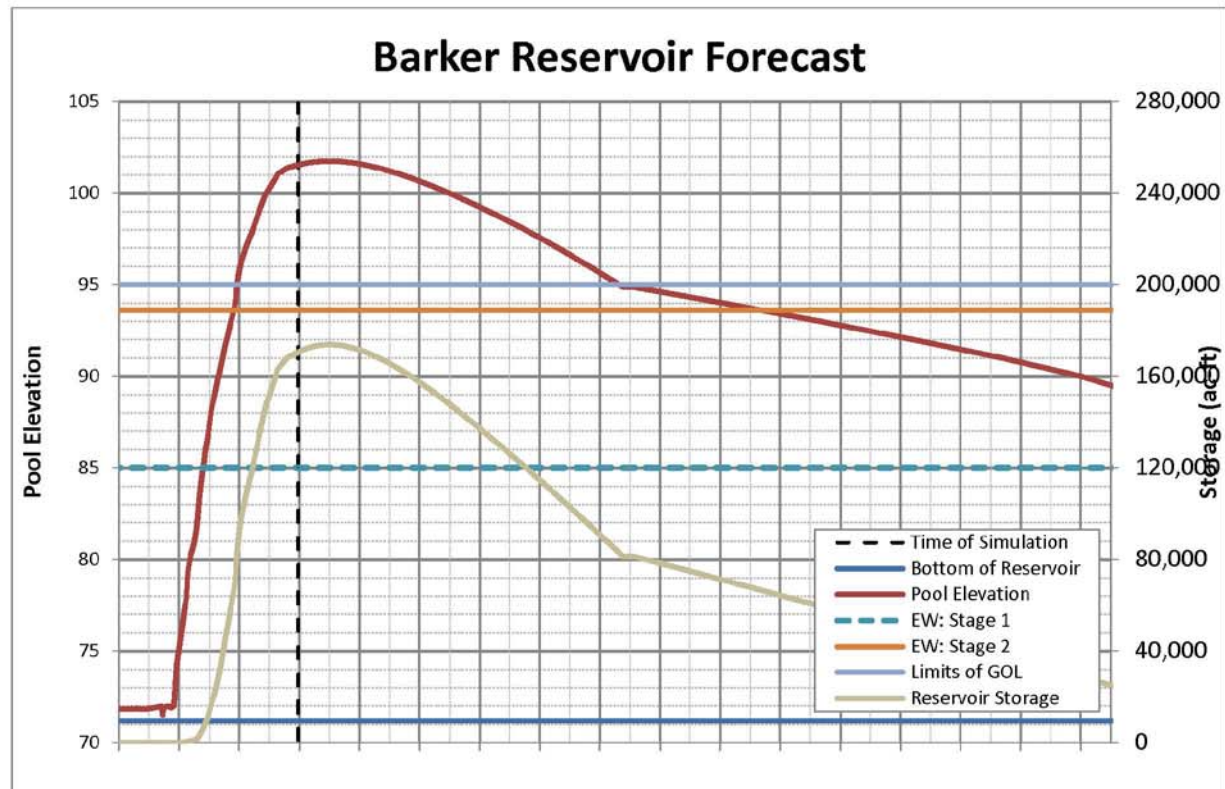


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 8/31/2017

The Addicks and Barker watersheds have received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 3 days ago. The 7-day accumulation assumed for this forecast is less than one inch.

Both pools peaked yesterday morning. At this time, Addicks is releasing approximately 7000 cfs and Barker is releasing approximately 6300 cfs. Flows around the north end of Addicks began 2 days ago, and at current discharge rates should cease on Saturday, September 2. Elevated discharges are expected to continue for at least 10+ days, before resuming normal rates of less than 4000 cfs combined total discharge.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

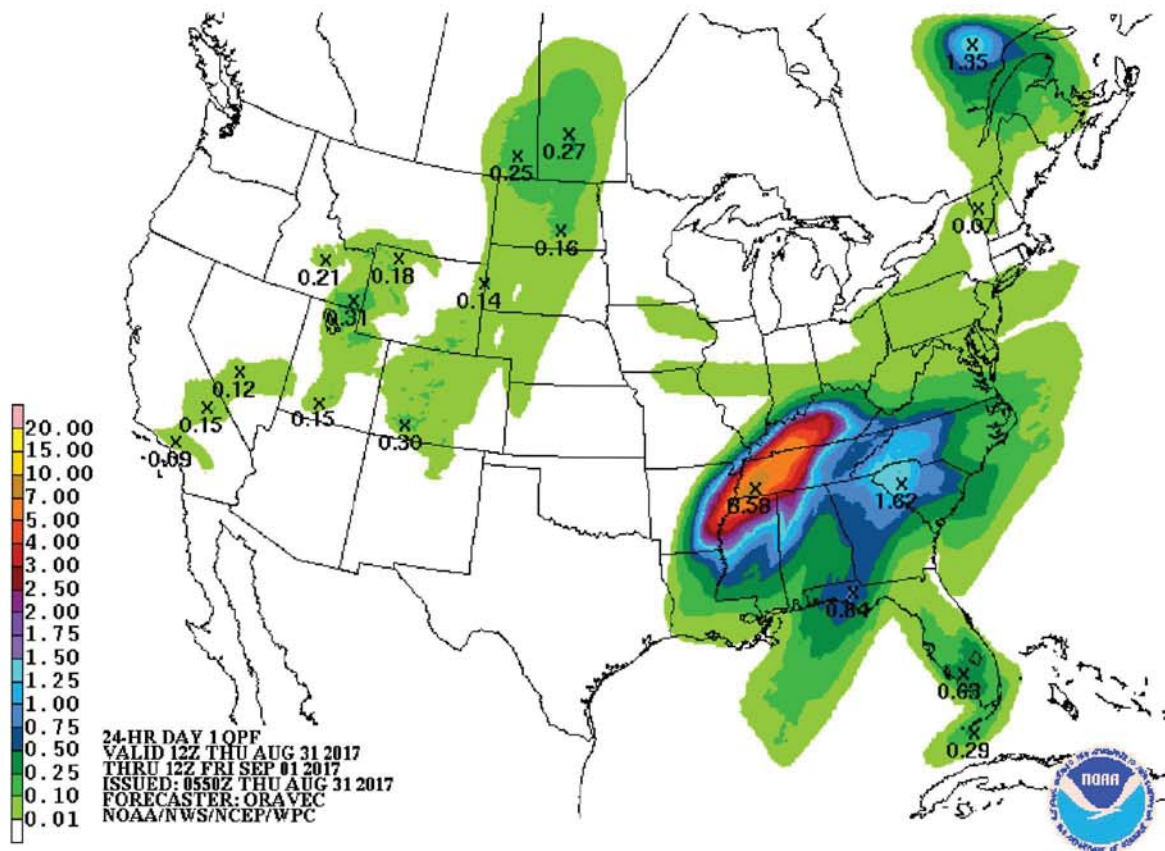
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 11:30 | 94.7 | 27 Aug 2017, 22:00 |
| Government Owned Land | 103 | 28 Aug 2017, 07:15 | 95 | 27 Aug 2017, 22:45 |
| first home flooded | 103.4 | 28 Aug 2017, 09:15 | 97.1 | 28 Aug 2017, 06:00 |
| Mandatory Releases begin | | 28 Aug 2017, 01:00 | | 28 Aug 2017, 01:00 |
| End of Dam | 108 | 29 Aug 2017, 07:15 | 104 | N/A |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |

Forecast Information:

- Forecast Start Time: 8/31/2017 00:00
- Lookback Period: 7 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 109.01 ft (NAVD) (08/31/2017 03:00 elevation 108.99)
 - Barker: 101.37 ft (NAVD) (08/31/2017 03:00 elevation 101.31)
- Predicted reservoir flows shown on Pages 4 & 5
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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24-hour QPF

Forecasted by:
M30DXMGK

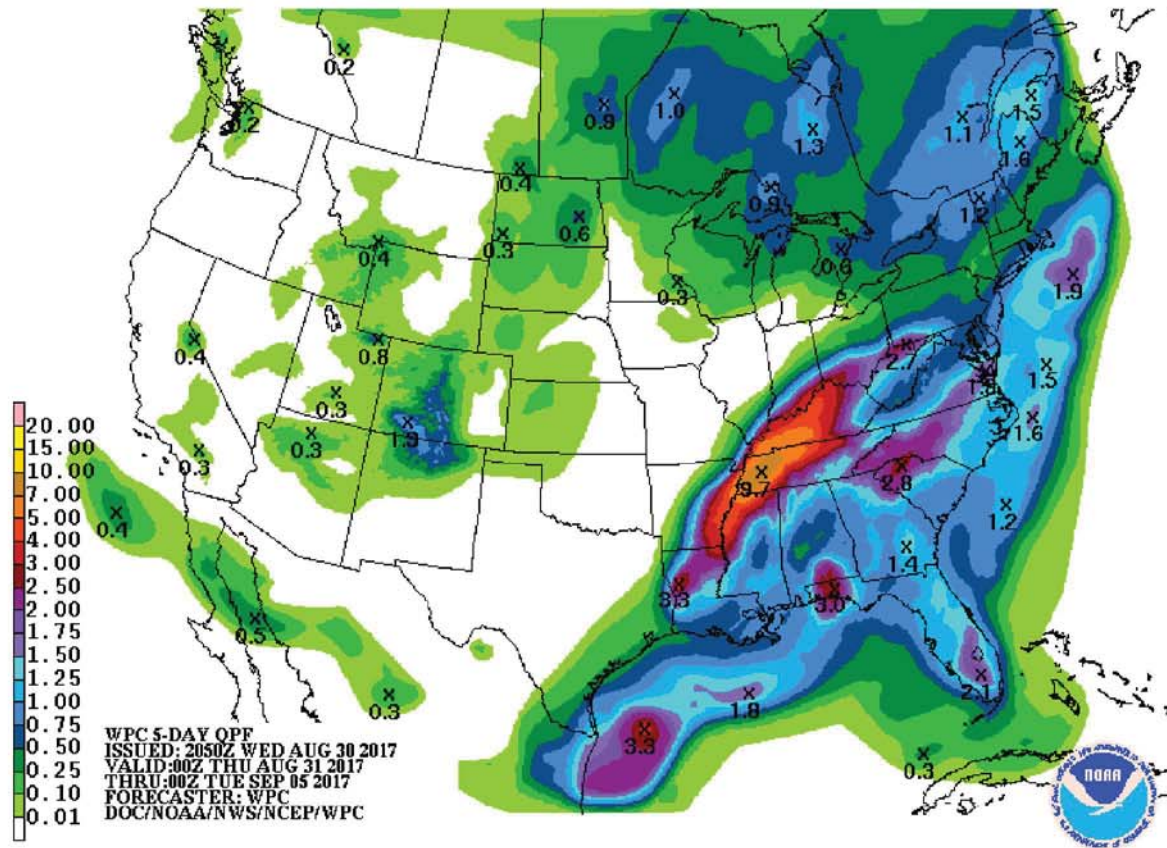
Page 2 of 5

Forecasted on:
31-Aug-17

USACE005909

U.S. Army Corps of Engineers
Galveston District

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5-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
31-Aug-17

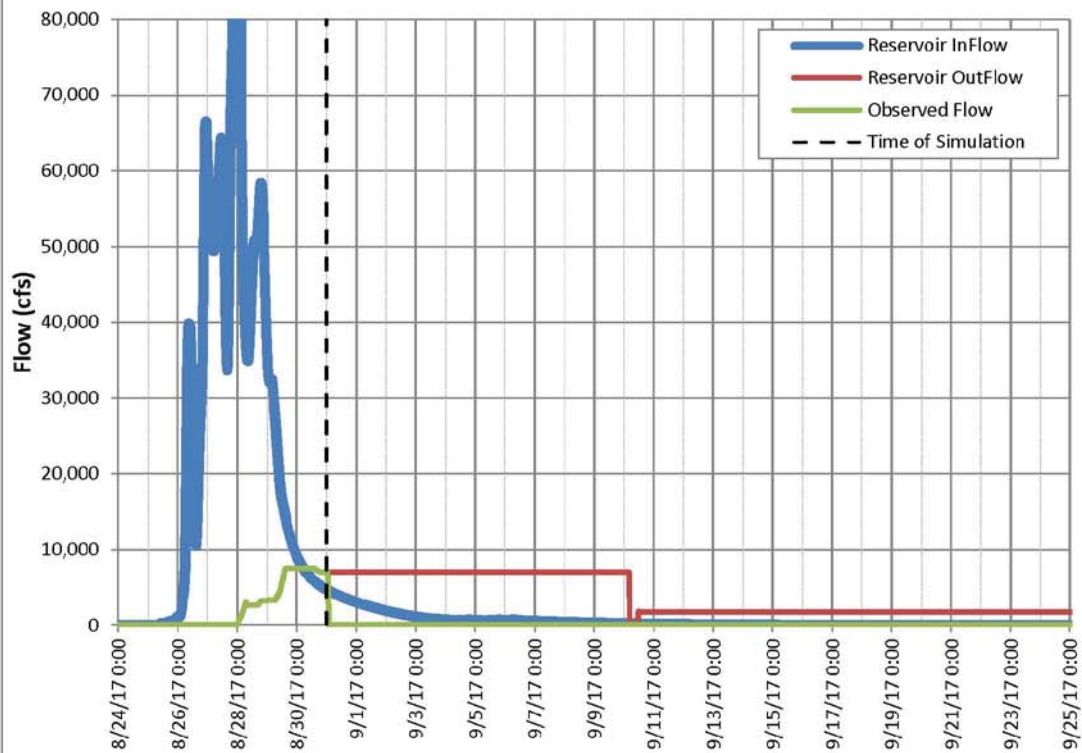
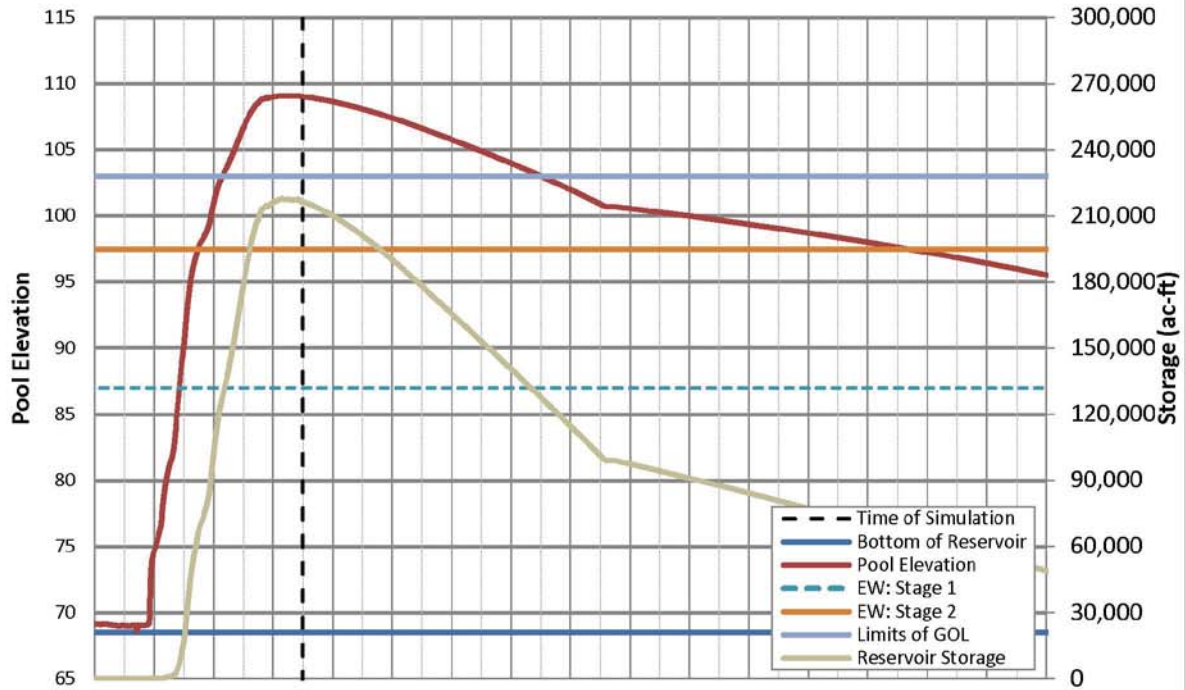
USACE005910

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

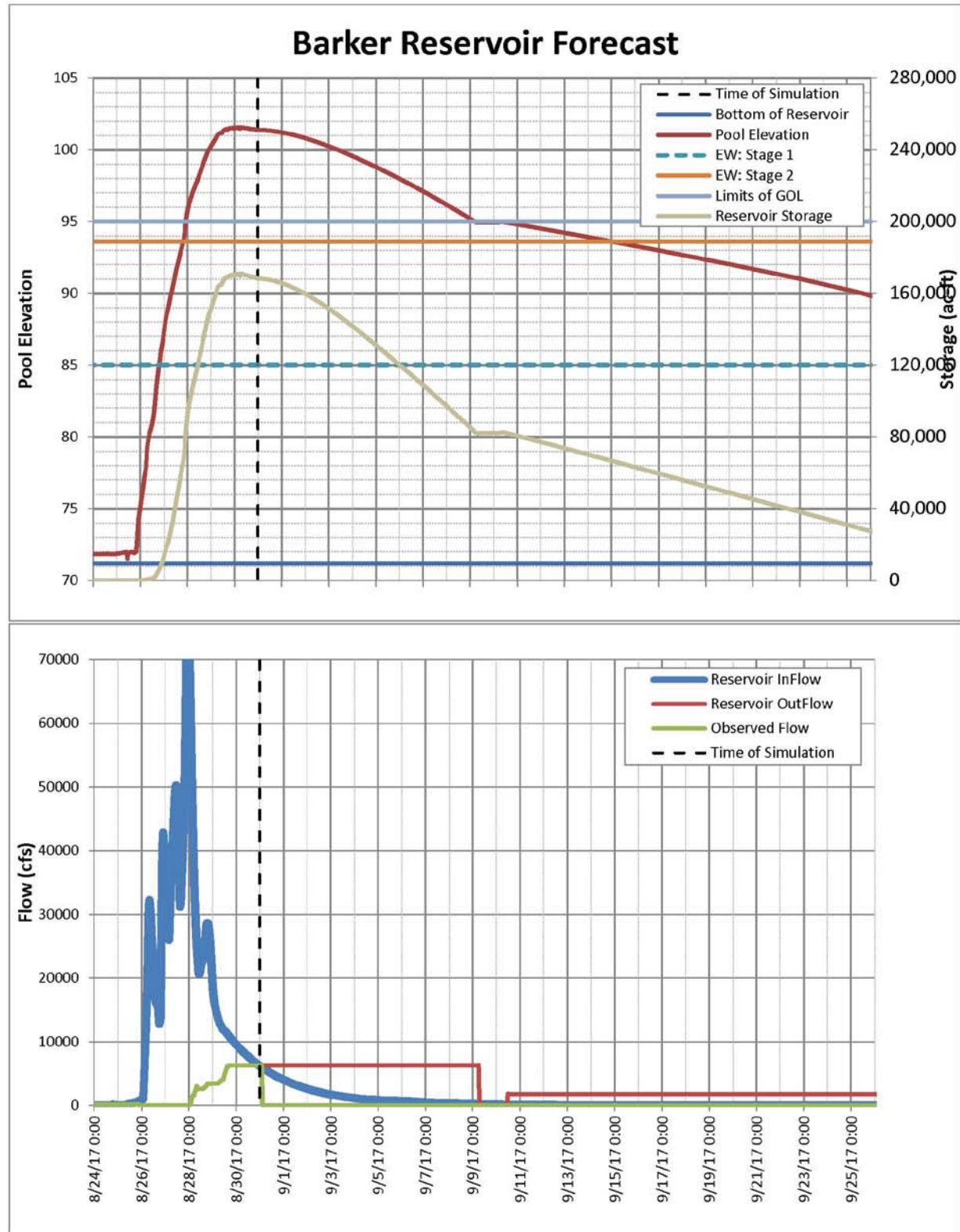
Page 4 of 5

Forecasted on:
31-Aug-17

USACE005911

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/1/2017

The Addicks and Barker watersheds received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 4 days ago. The 7-day accumulation assumed for this forecast is less than one inch.

Both pools peaked Wednesday morning. At this time, Addicks is releasing approximately 7000 cfs and Barker is releasing approximately 6300 cfs. Flows around the north end of Addicks began 3 days ago, and at current discharge rates will cease tomorrow. Elevated discharges are expected to continue for at least 10 days, before resuming normal rates of less than 4000 cfs combined total discharge.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

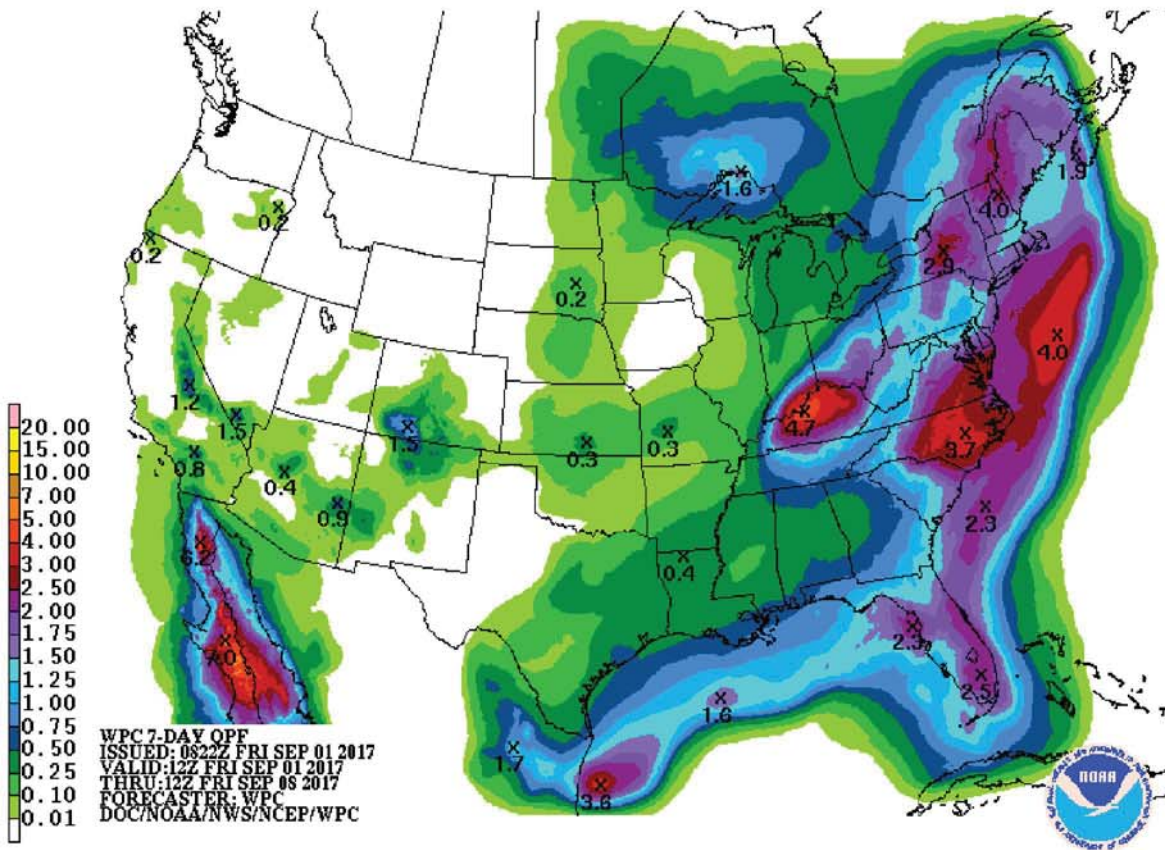
| Forecast Summary for QPF | | | | |
|--------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| EW, Stage 1 Res. Level | 87 | 26 Aug 2017, 20:30 | 85 | 26 Aug 2017, 19:15 |
| EW, Stage 2 Res. Level | 97.46 | 27 Aug 2017, 11:30 | 93.6 | 27 Aug 2017, 22:00 |
| Government Owned Land | 103 | 28 Aug 2017, 07:15 | 95 | 27 Aug 2017, 22:45 |
| first home flooded | 103.4 | 28 Aug 2017, 09:15 | 97.1 | 28 Aug 2017, 06:00 |
| Mandatory Releases begin | | 28 Aug 2017, 01:00 | | 28 Aug 2017, 01:00 |
| End of Dam | 108 | 29 Aug 2017, 07:15 | 104 | N/A |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |

Forecast Information:

- Forecast Start Time: 9/1/2017 01:00
- Lookback Period: 8 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 108.53 ft (NAVD)
 - Barker: 100.79 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
1-Sep-17

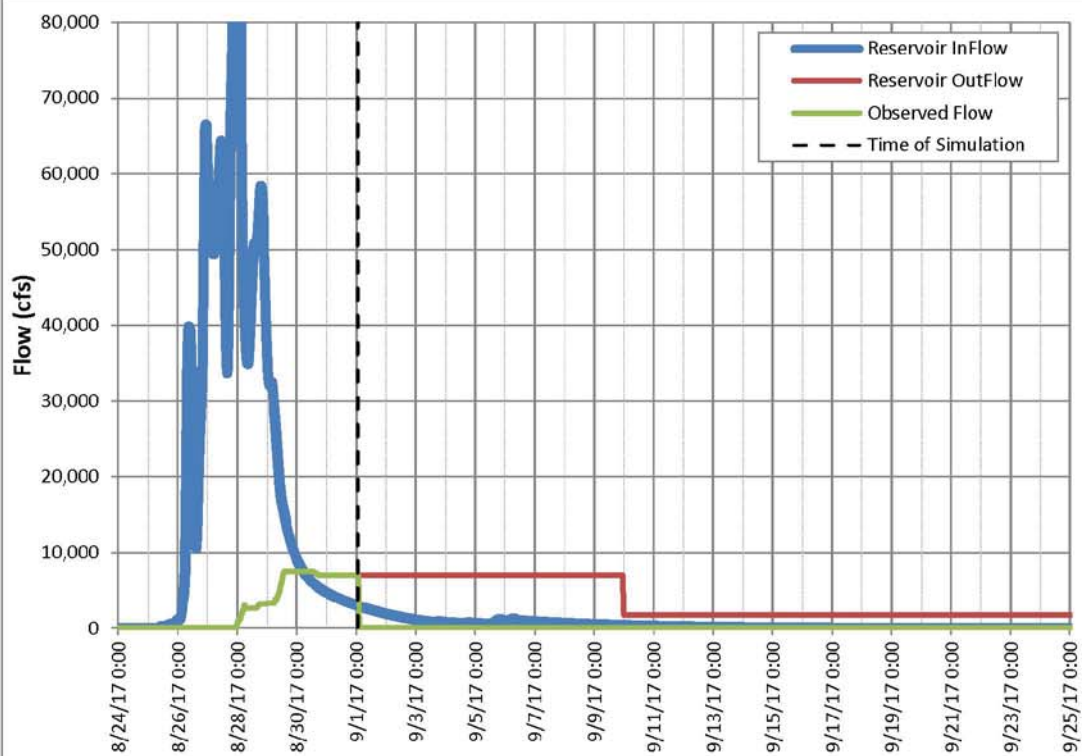
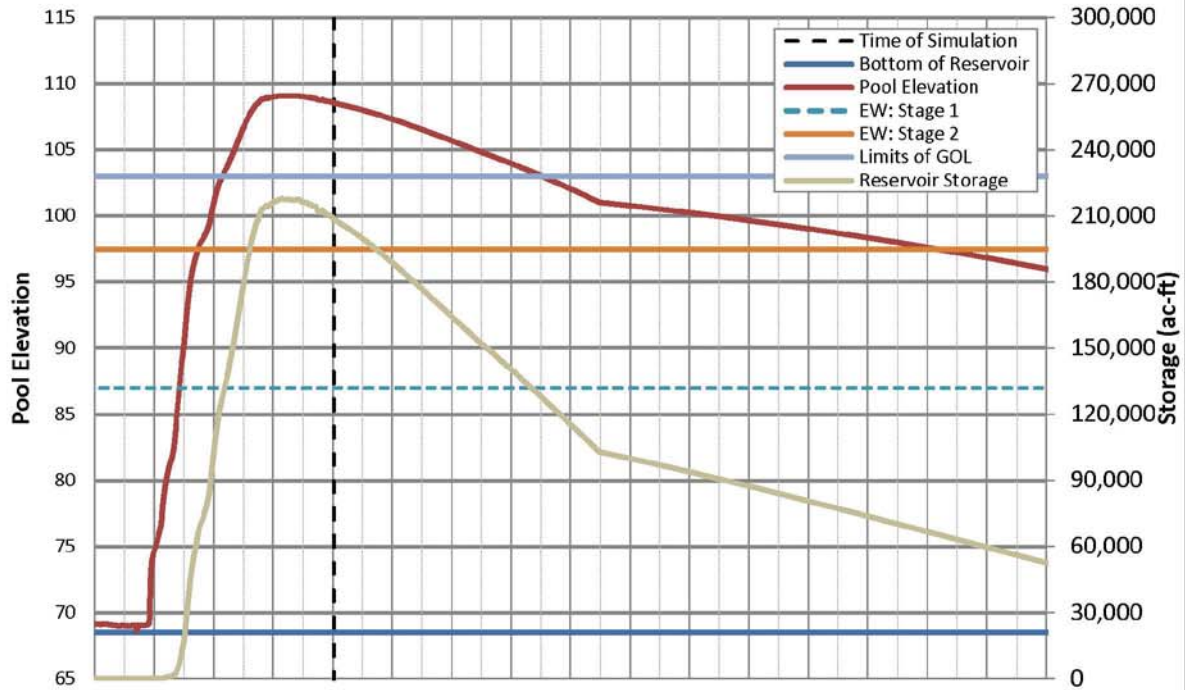
USACE005914

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

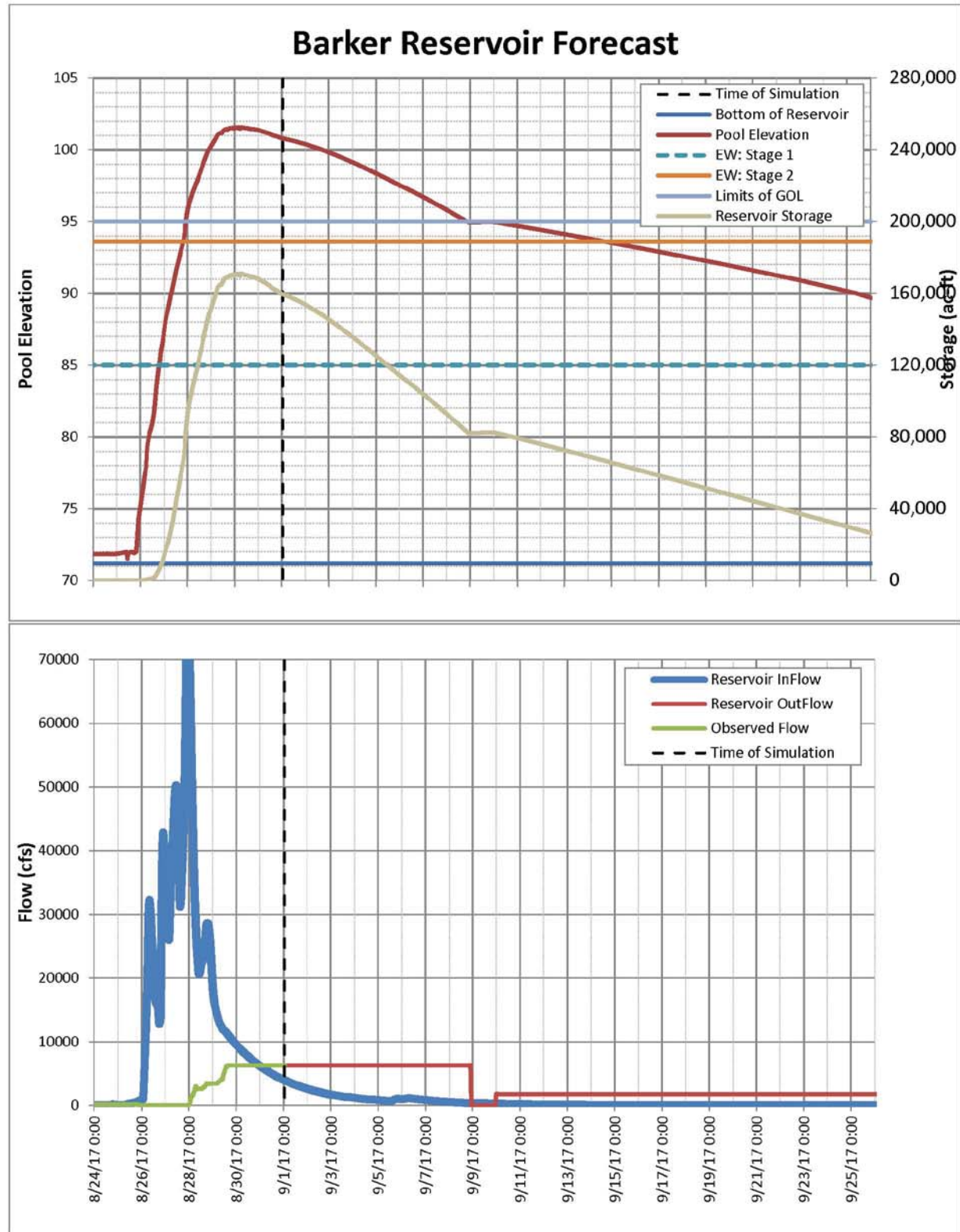
Page 3 of 4

Forecasted on:
1-Sep-17

USACE005915

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/2/2017

The Addicks and Barker watersheds received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 5 days ago. Both pools peaked Wednesday morning. Flow around the north end of Addicks has ceased since the pool has dropped below elevation 108. The 7-day accumulation assumed for this forecast is less than one inch, with the most likely chance of rain on Tuesday/Wednesday.

At this time, Addicks is releasing approximately 7000 cfs and Barker is releasing approximately 6300 cfs. This forecast includes a prospective drawdown on discharges to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15-17.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

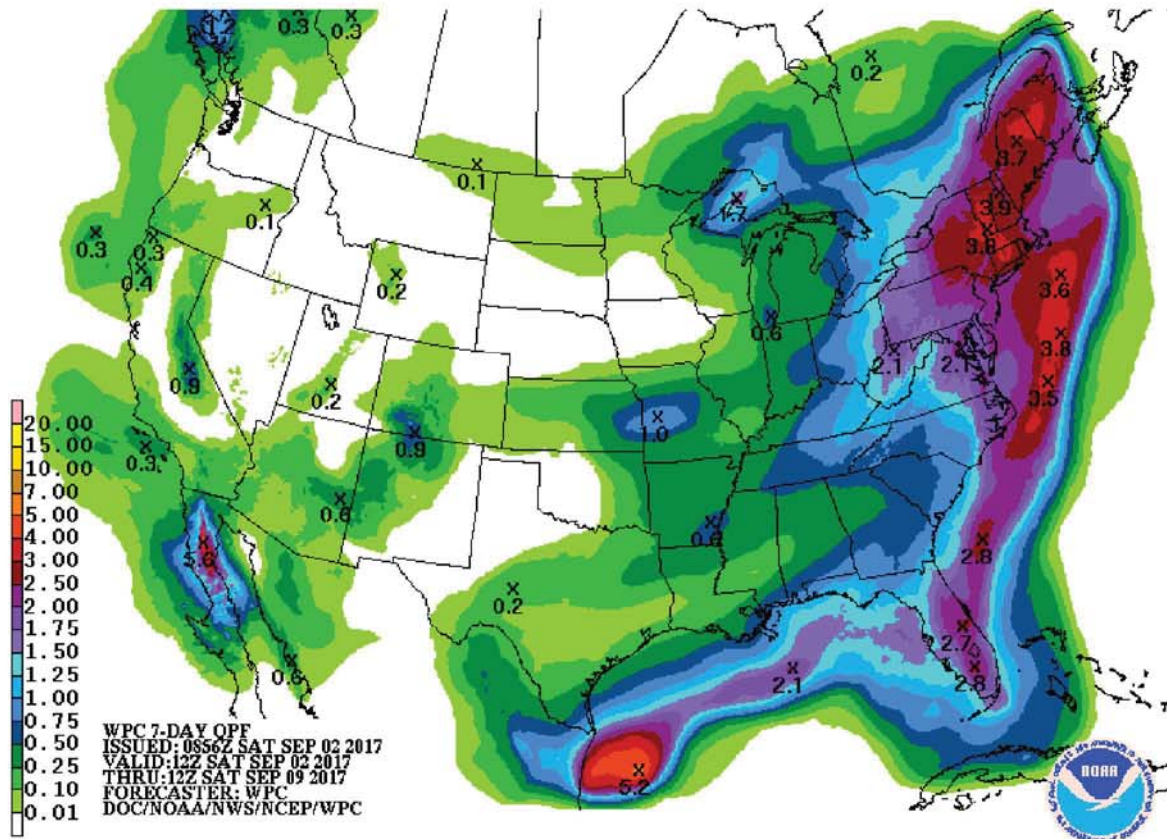
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 07 Sep 2017, 13:00 | 97.1 | 06 Sep 2017, 15:00 |
| Government Owned Land | 103 | 07 Sep 2017, 23:00 | 95 | 09 Sep 2017, 14:00 |
| EW, Stage 2 Res. Level | 97.46 | 12 Sep 2017, 23:00 | 93.6 | 12 Sep 2017, 03:00 |
| Empty | 67.5 | 5-6 weeks | 70.2 | 5-6 weeks |

Forecast Information:

- Forecast Start Time: 9/2/2017 02:00
- Lookback Period: 9 days
- Forecast End Time: 9/24/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 107.84 ft (NAVD)
 - Barker: 100.08 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-

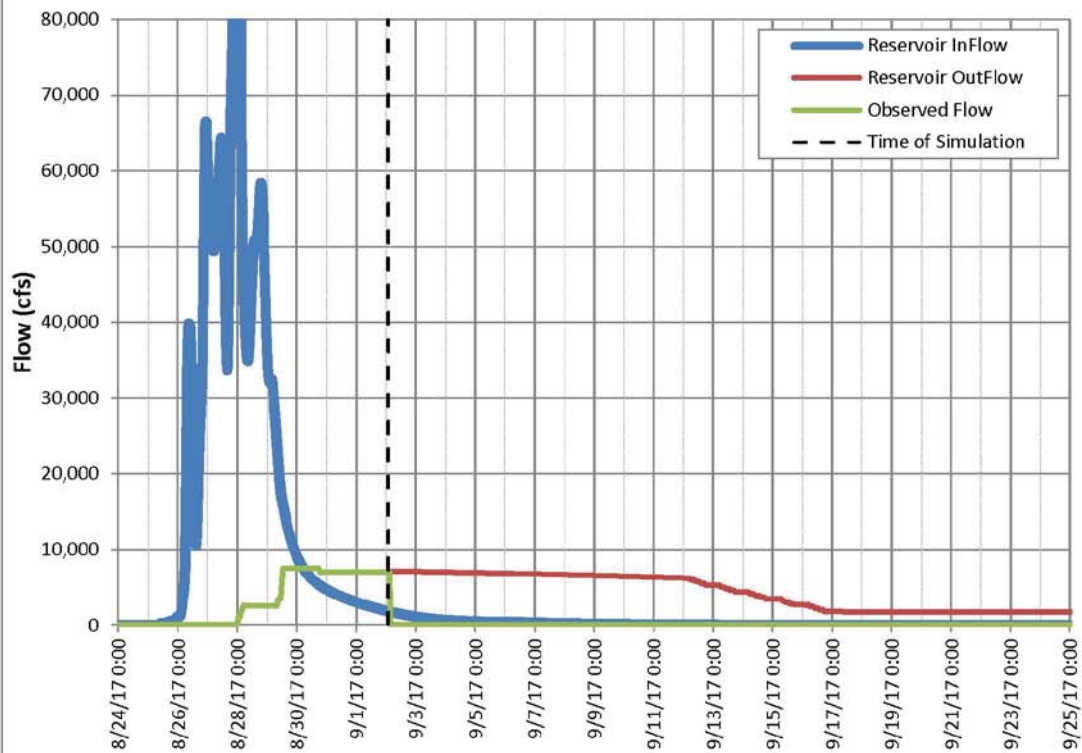
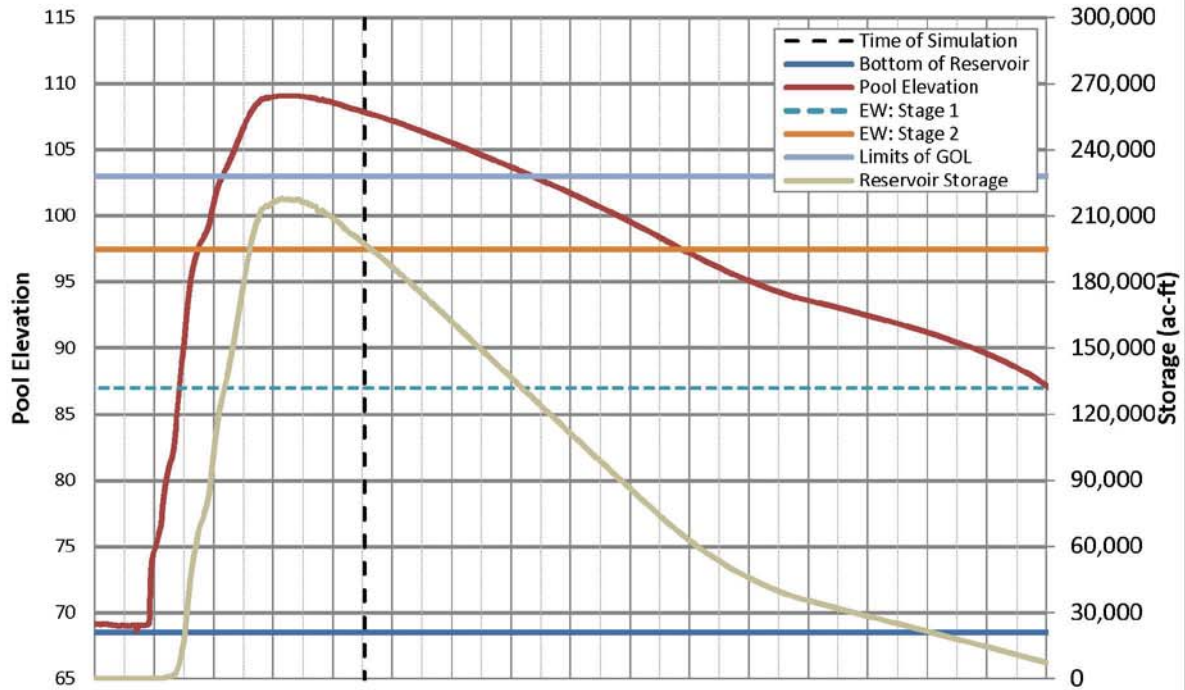
day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

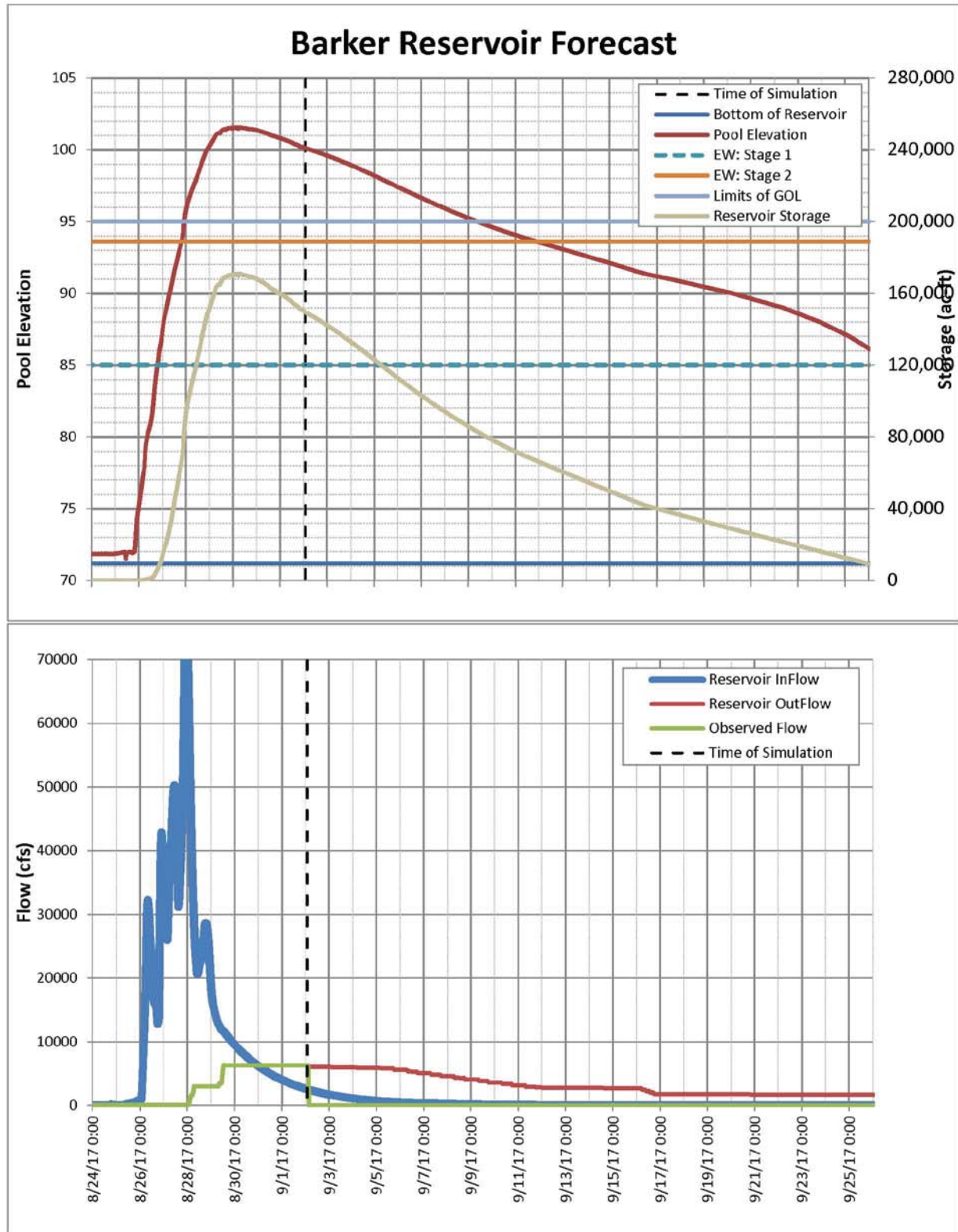
Page 3 of 4

Forecasted on:
2-Sep-17

USACE005919

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/3/2017

The Addicks and Barker watersheds received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 6 days ago. Both pools peaked Wednesday morning. Flow around the north end of Addicks has ceased since the pool has dropped below elevation 108. The 7-day accumulation assumed for this forecast is less than one inch, with the most likely chance of rain on Tuesday/Wednesday.

At this time, Addicks is releasing approximately 7000 cfs and Barker is releasing approximately 6300 cfs. This forecast includes a prospective drawdown on discharges to protect both the dam faces and bayou banks, beginning today. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

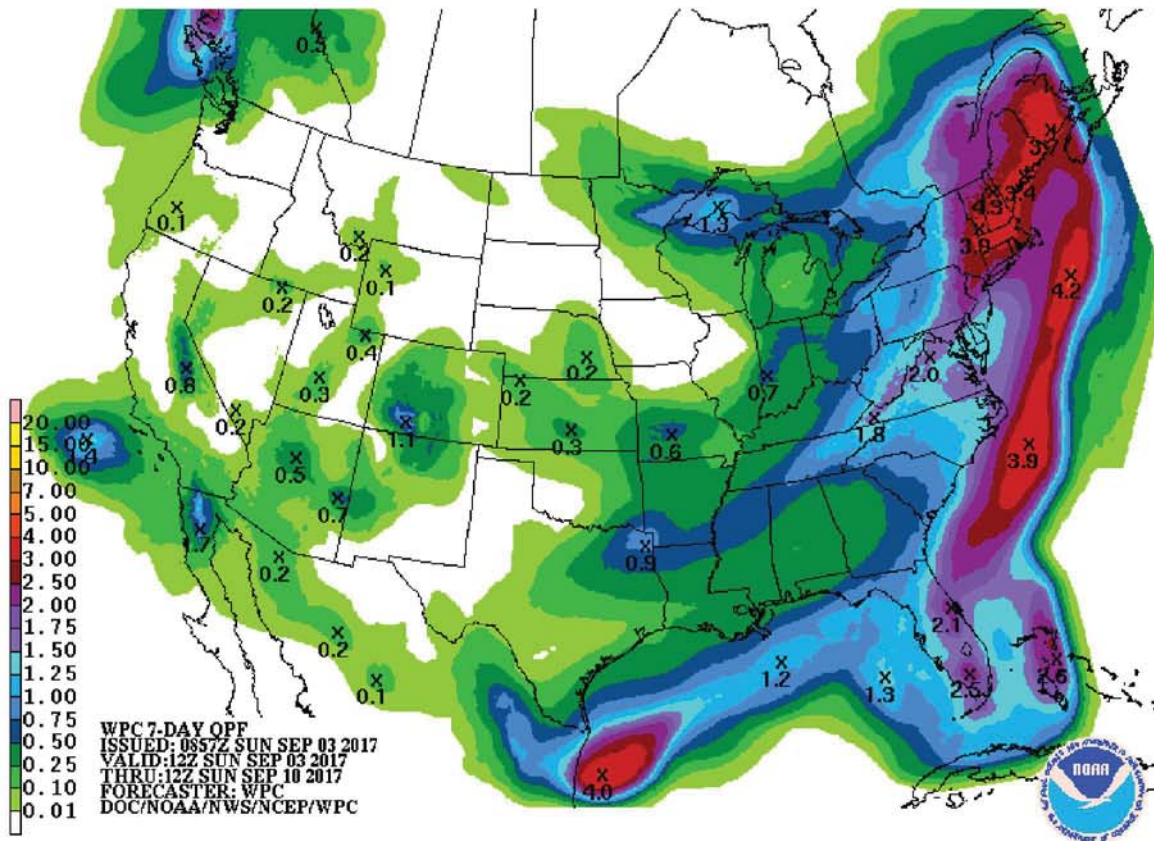
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 07 Sep 2017, 7:00 | 97.1 | 06 Sep 2017, 12:00 |
| Government Owned Land | 103 | 07 Sep 2017, 17:00 | 95 | 10 Sep 2017, 10:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 06:00 | 93.6 | 15 Sep 2017, 14:00 |
| Empty | 67.5 | 5-6 weeks | 70.2 | 5-6 weeks |

Forecast Information:

- Forecast Start Time: 9/3/2017 01:00
- Lookback Period: 10 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 107.16 ft (NAVD)
 - Barker: 99.37 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M3ODXMGK

Page 2 of 4

Forecasted on:
3-Sep-17

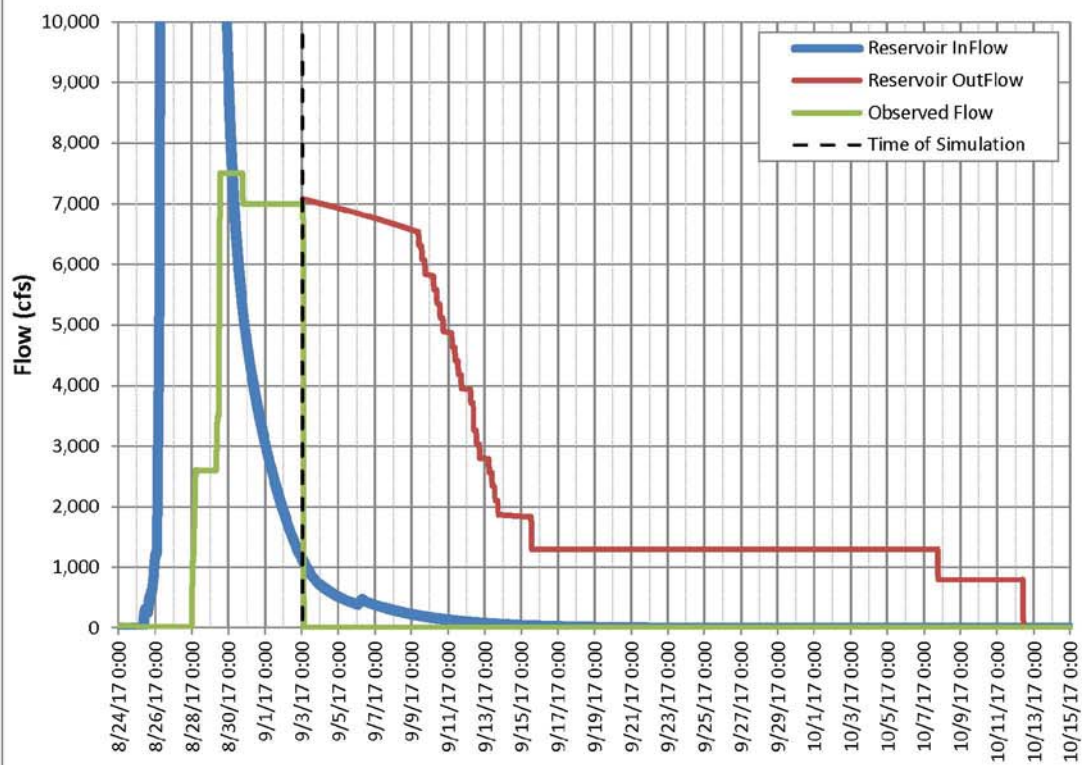
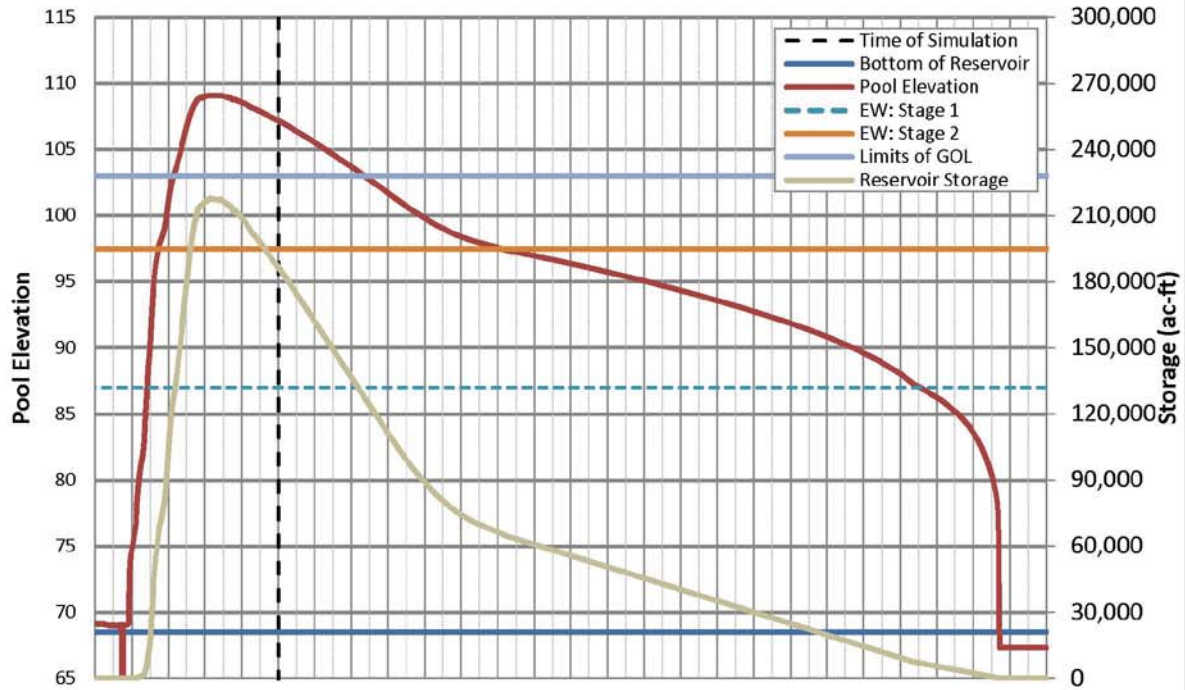
USACE005922

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

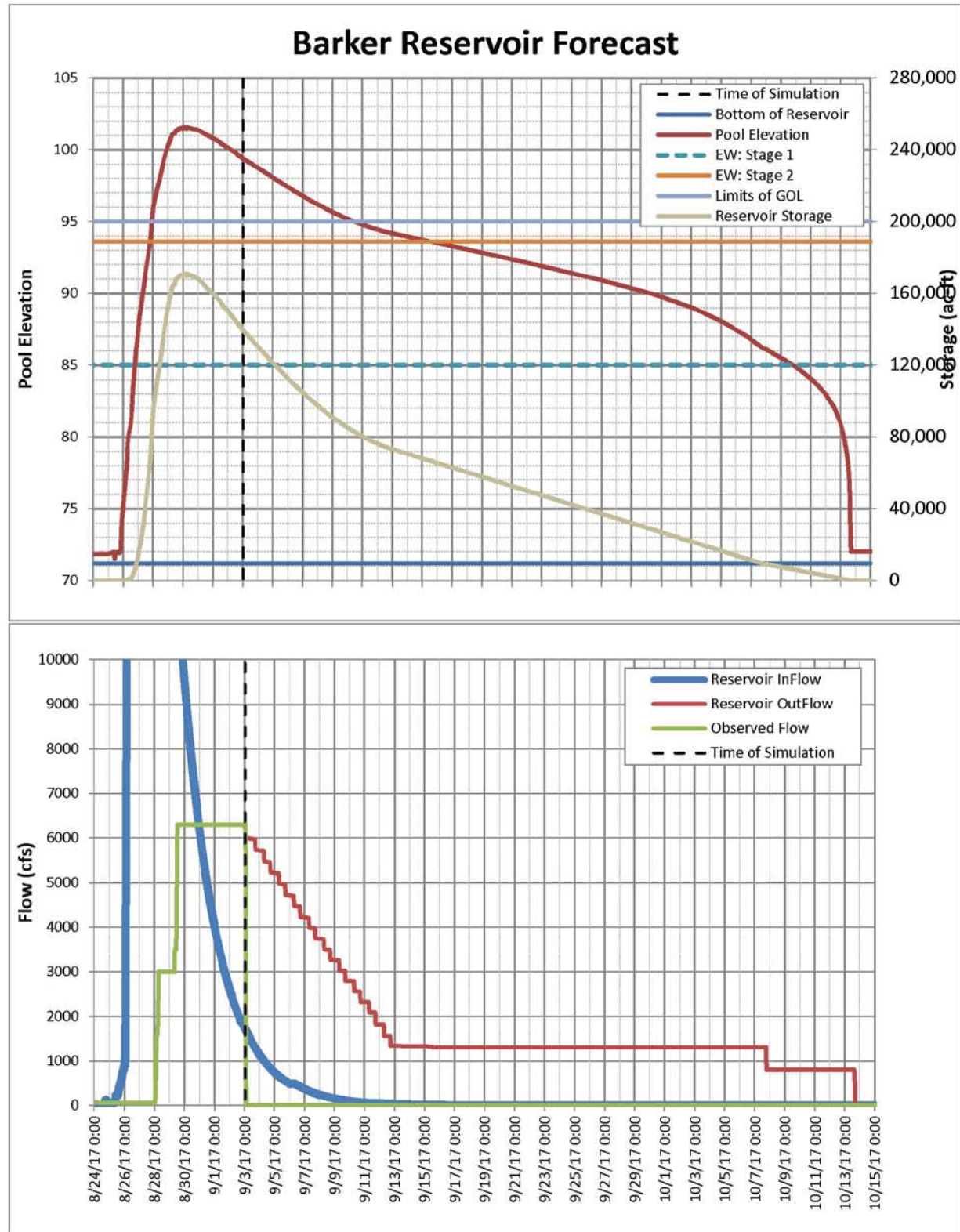
Page 3 of 4

Forecasted on:
3-Sep-17

USACE005923

U.S. Army Corps of Engineers
Galveston District

DRAFT



Forecasted by:
M3ODXMGK

Page 4 of 4

Forecasted on:
3-Sep-17

USACE005924



CWMS Forecast: 9/4/2017

The Addicks and Barker watersheds received 32-35 inches across the watersheds since the beginning of this event. Releases from both reservoirs began 6 days ago. The gates on Barker Reservoir were closed 1 gate-foot last night. The 7-day accumulation assumed for this forecast is less than one inch, with the most likely chance of rain on Tuesday/Wednesday.

At this time, Addicks is releasing approximately 6900 cfs and Barker is releasing approximately 5700 cfs. This forecast includes the prospective drawdown on discharges, which will be enacted to protect both the dam faces and bayou banks, beginning today. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

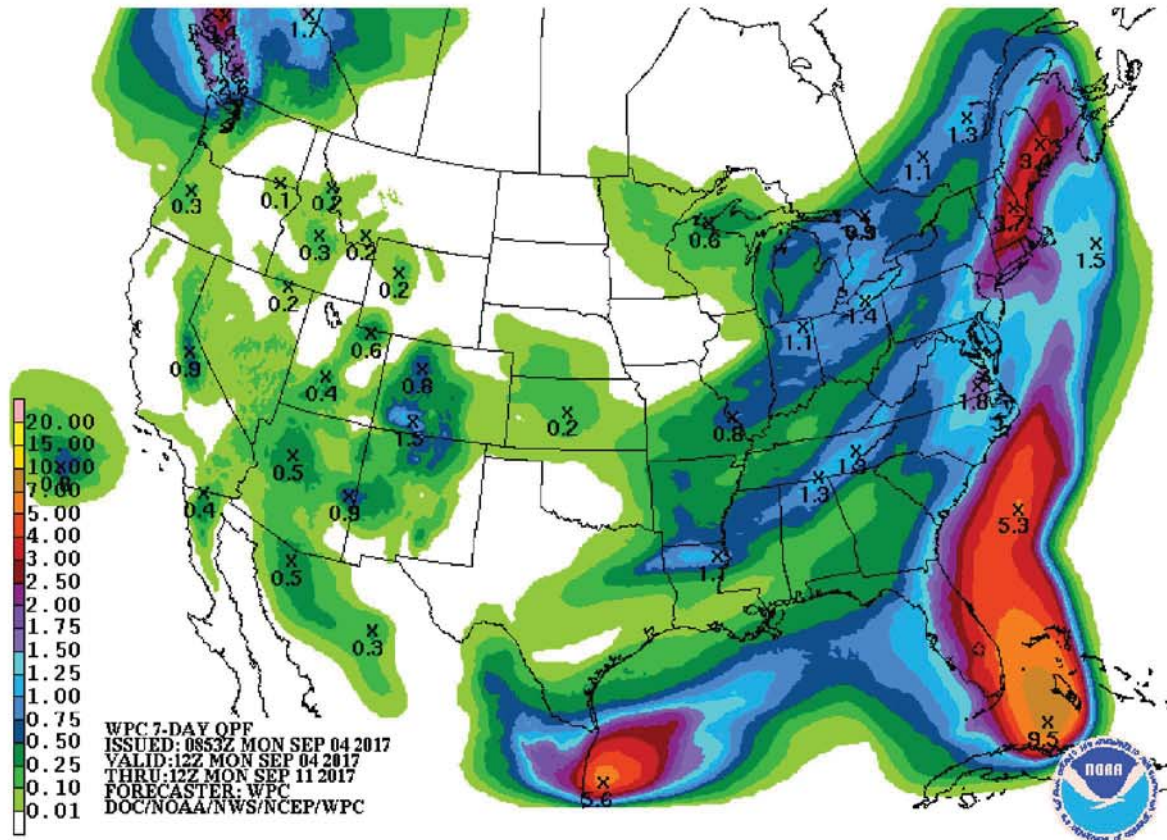
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 07 Sep 2017, 07:00 | 97.1 | 06 Sep 2017, 7:00 |
| Government Owned Land | 103 | 07 Sep 2017, 17:00 | 95 | 10 Sep 2017, 2:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 08:00 | 93.6 | 15 Sep 2017, 4:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/4/2017 02:00
- Lookback Period: 11 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 106.33 ft (NAVD)
 - Barker: 98.57 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
4-Sep-17

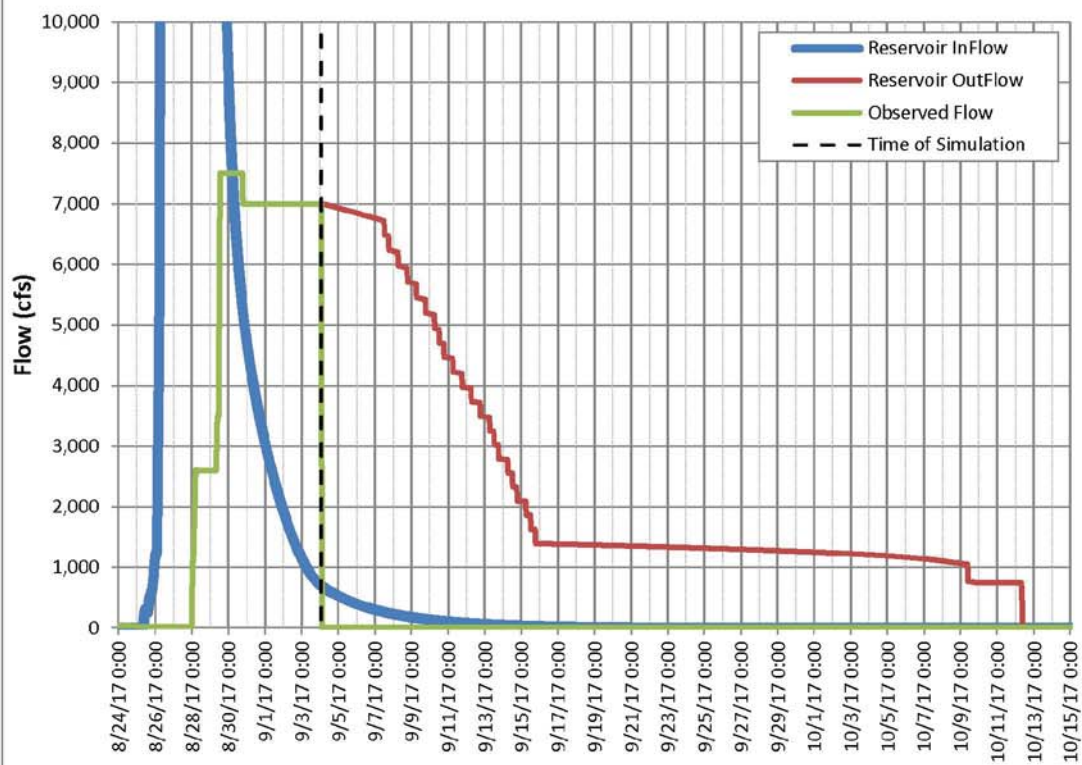
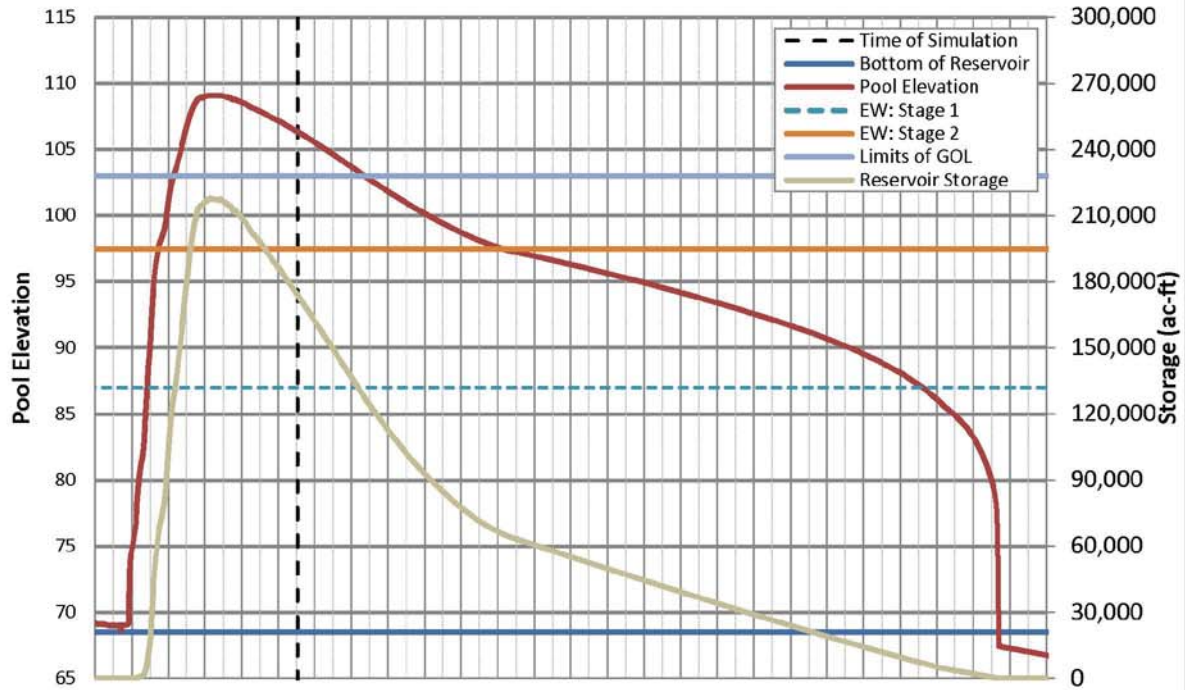
USACE005926

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

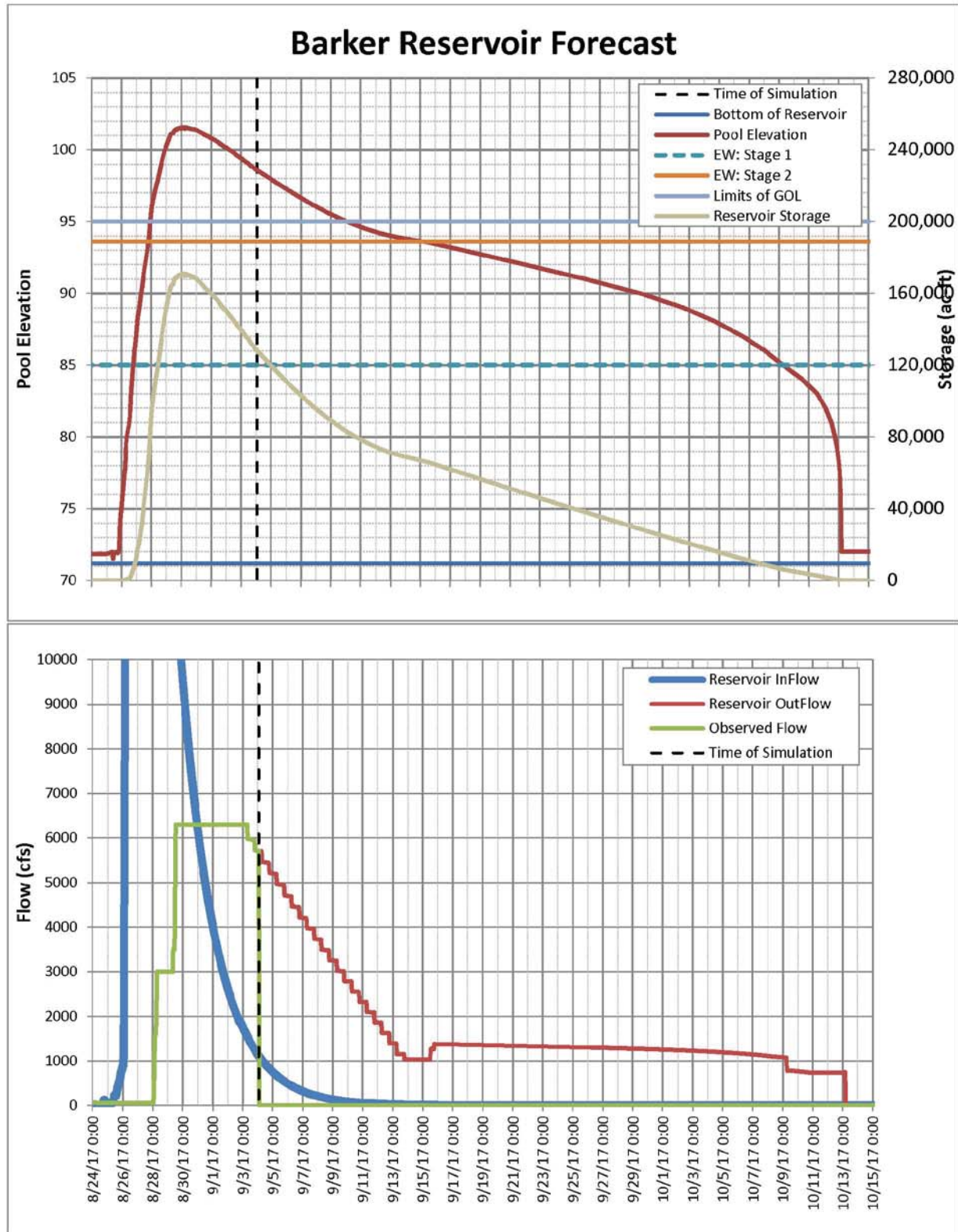
Page 3 of 4

Forecasted on:
4-Sep-17

USACE005927

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/5/2017

The Addicks and Barker watersheds received 32-35 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 7 days ago. The gates on Barker Reservoir are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 6900 cfs and Barker is releasing approximately 5100 cfs. This forecast includes the prospective drawdown on discharges, which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

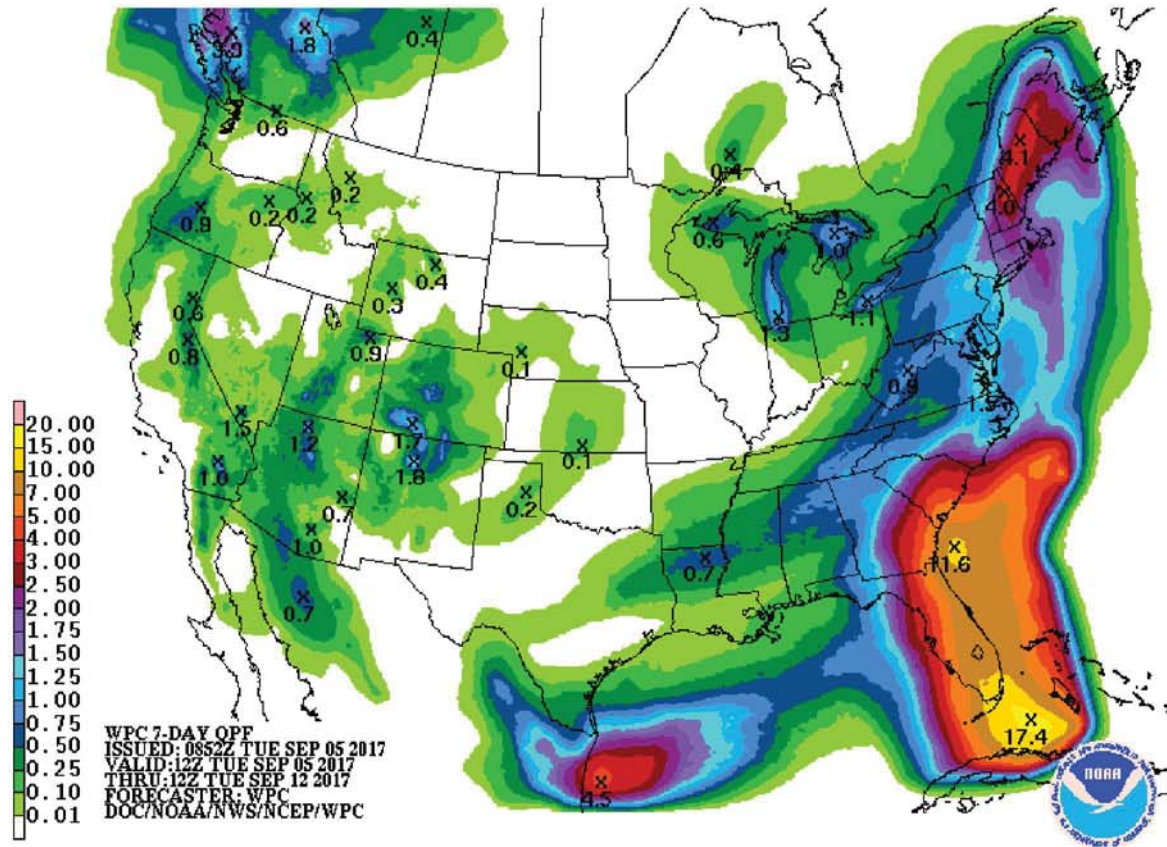
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 07 Sep 2017, 07:00 | 97.1 | 06 Sep 2017, 5:00 |
| Government Owned Land | 103 | 07 Sep 2017, 17:00 | 95 | 9 Sep 2017, 23:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 02:00 | 93.6 | 13 Sep 2017, 5:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/5/2017 02:00
- Lookback Period: 12 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 105.44 ft (NAVD)
 - Barker: 97.84 ft (NAVD)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M3ODXMGK

Page 2 of 4

Forecasted on:
5-Sep-17

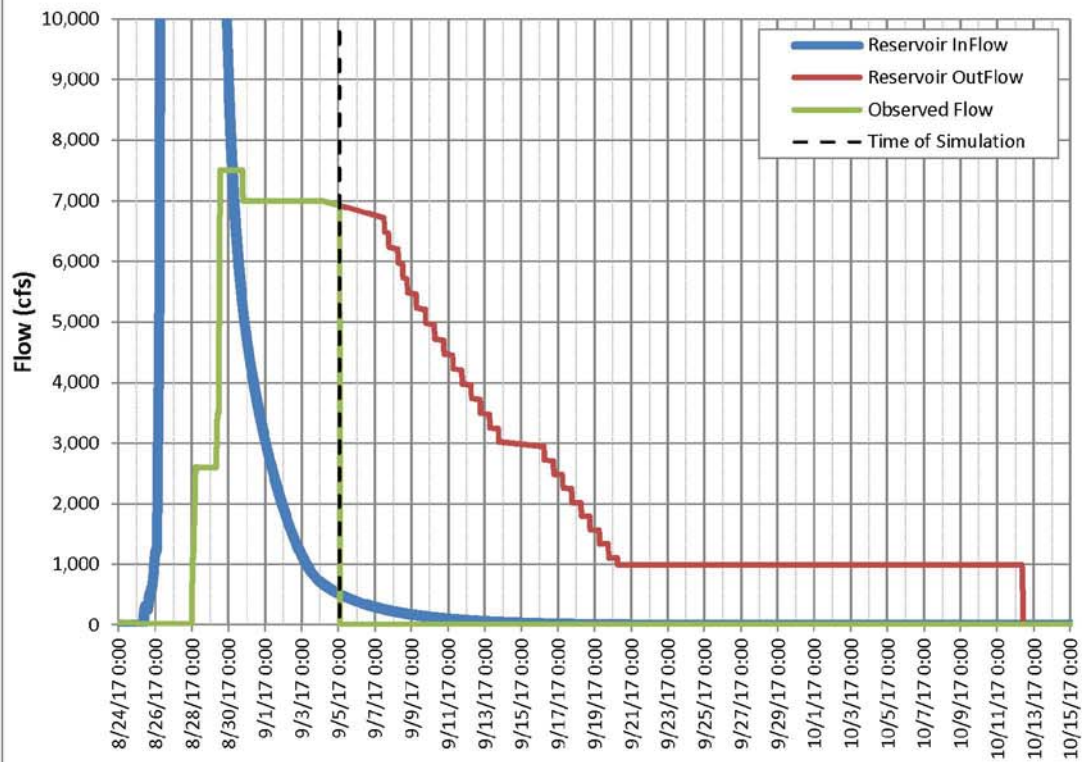
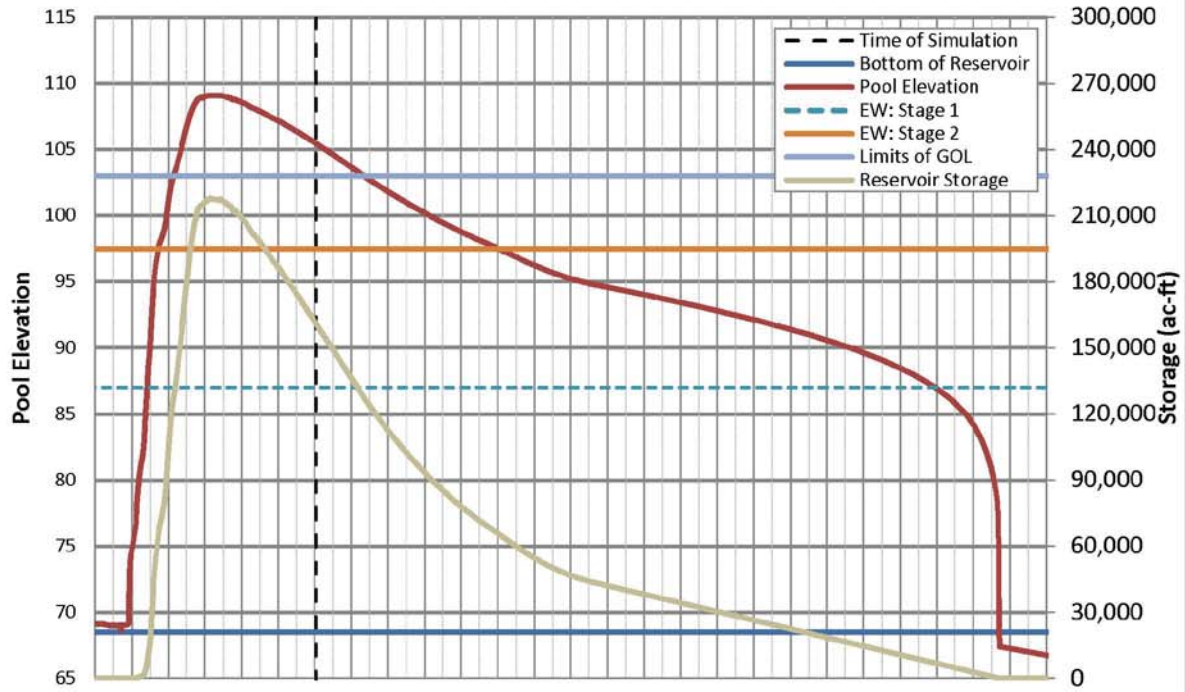
USACE005930

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

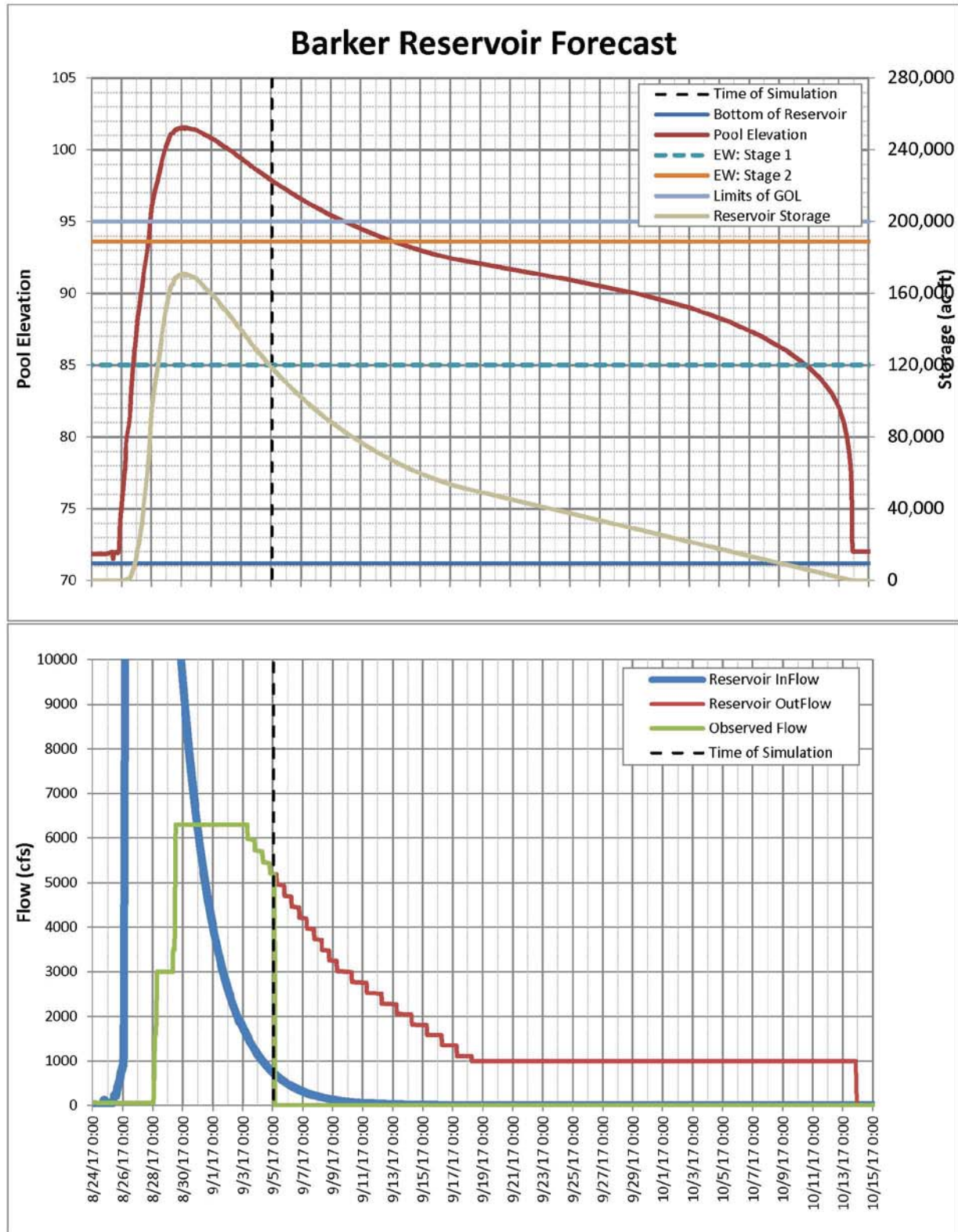
Page 3 of 4

Forecasted on:
5-Sep-17

USACE005931

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Galveston District

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CWMS Forecast: 9/6/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 8 days ago. The gates on Barker Reservoir are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 6800 cfs and Barker is releasing approximately 4700 cfs. In the next few hours, the pool in Barker Reservoir should be below the finish floor elevation of all homes within the reservoir. This forecast includes the prospective drawdown on discharges, which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

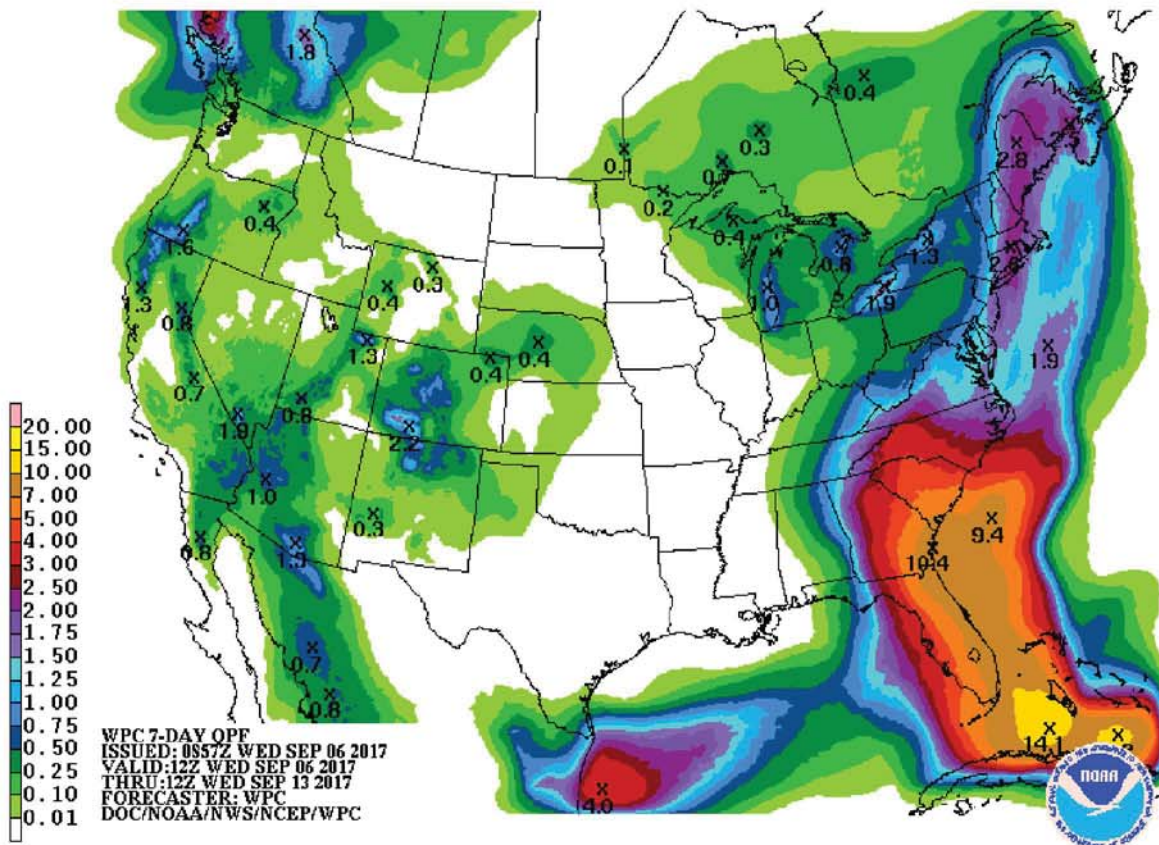
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 07 Sep 2017, 07:00 | 97.1 | 06 Sep 2017, 4:00 |
| Government Owned Land | 103 | 07 Sep 2017, 10:00 | 95 | 9 Sep 2017, 24:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 08:00 | 93.6 | 13 Sep 2017, 8:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/6/2017 02:00
- Lookback Period: 13 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 104.53 ft (NAVD88)
 - Barker: 97.16 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M3ODXMGK

Page 2 of 4

Forecasted on:
6-Sep-17

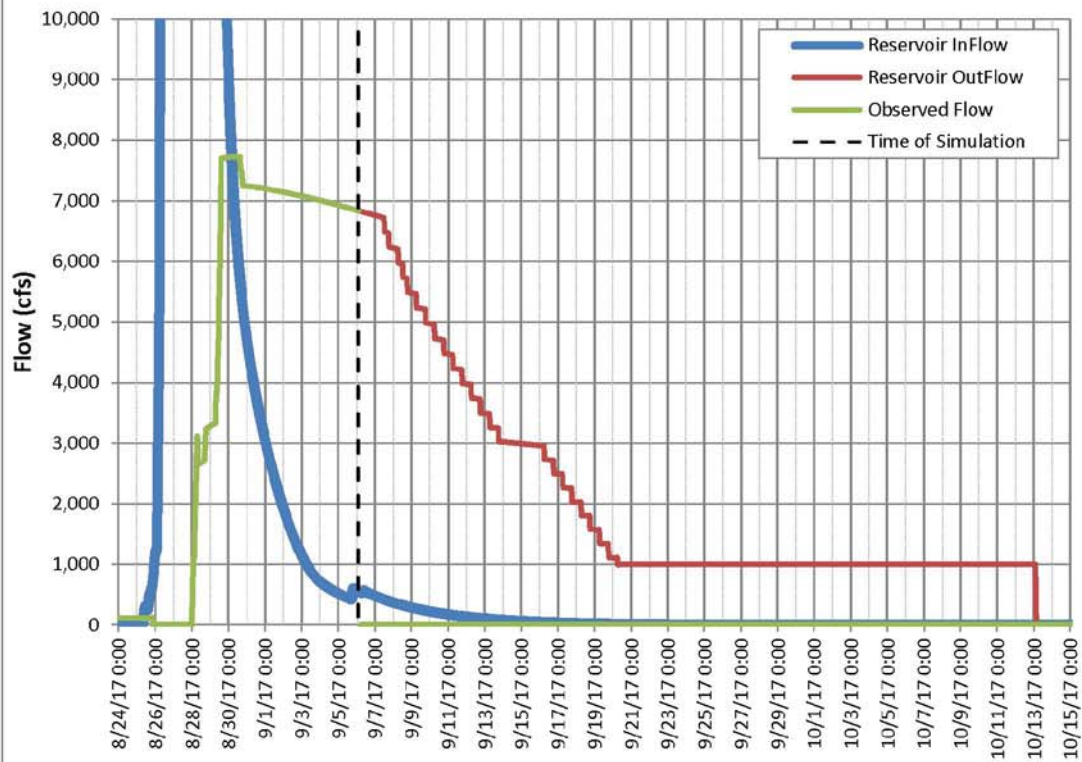
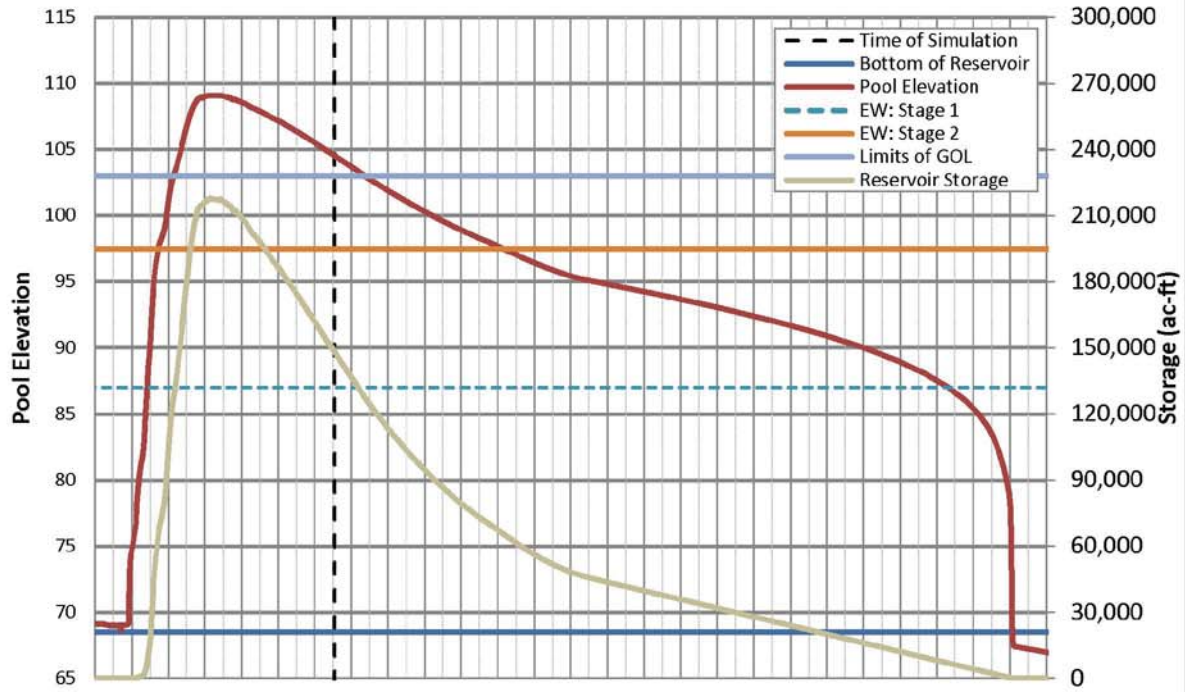
USACE005934

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

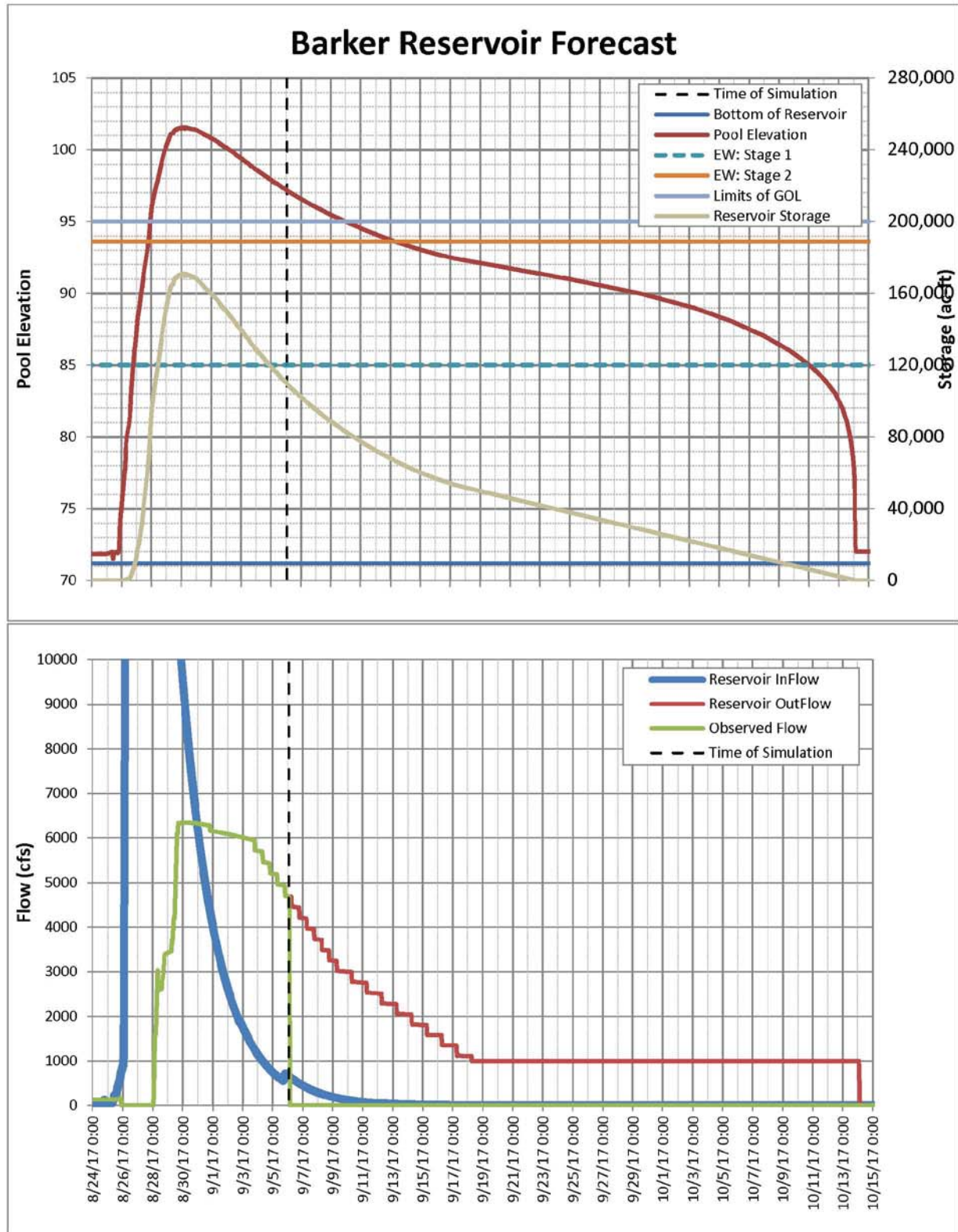
Page 3 of 4

Forecasted on:
6-Sep-17

USACE005935

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Galveston District

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CWMS Forecast: 9/7/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 9 days ago. The gates on Barker Reservoir are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 6700 cfs and Barker is releasing approximately 4200 cfs. In the next few hours, the pool in Addicks Reservoir should be below the finish floor elevation of all homes within the reservoir and then later on today, the entire pool should entirely be on government owned land. This forecast includes the prospective drawdown on discharges, which will be enacted to protect both the dam faces and bayou banks. Gate closures will begin on Addicks Reservoir later today as well. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

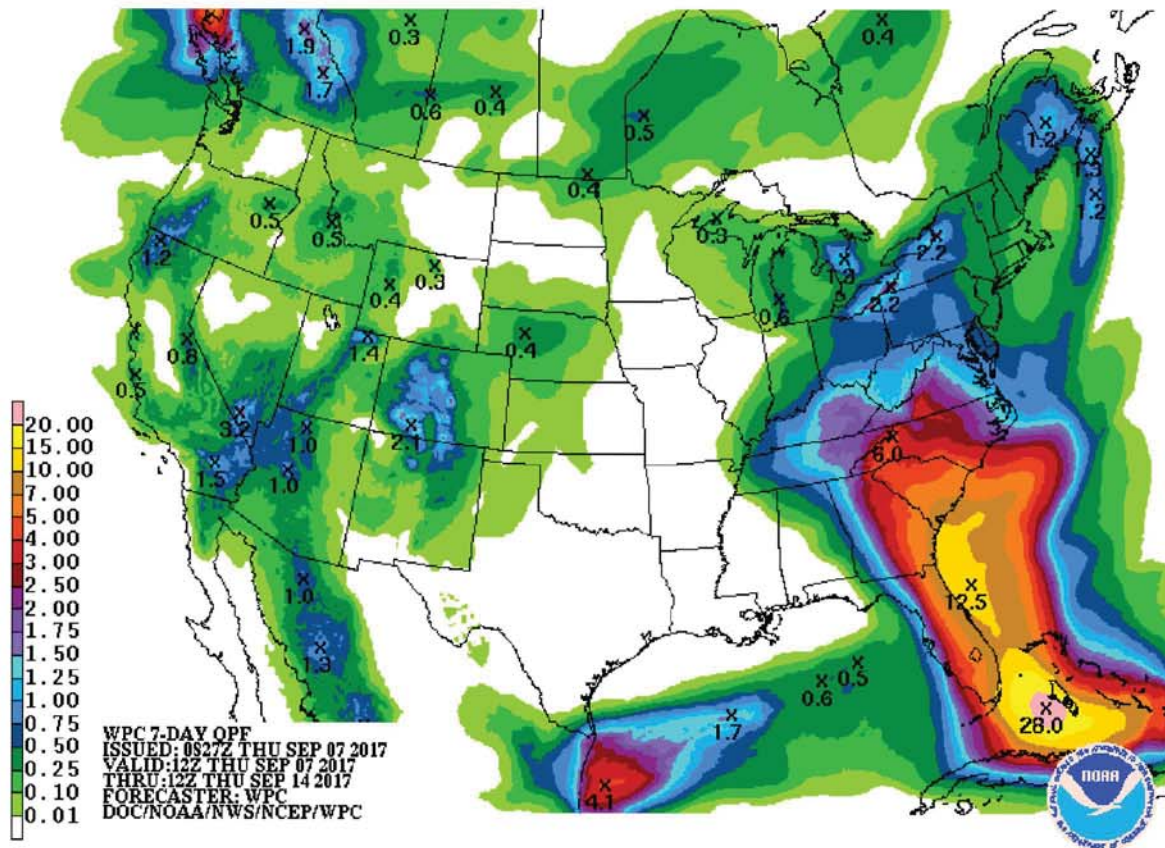
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 16:00 | 95 | 9 Sep 2017, 24:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 04:00 | 93.6 | 13 Sep 2017, 8:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/7/2017 03:00
- Lookback Period: 14 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 103.51 ft (NAVD88)
 - Barker: 96.52 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

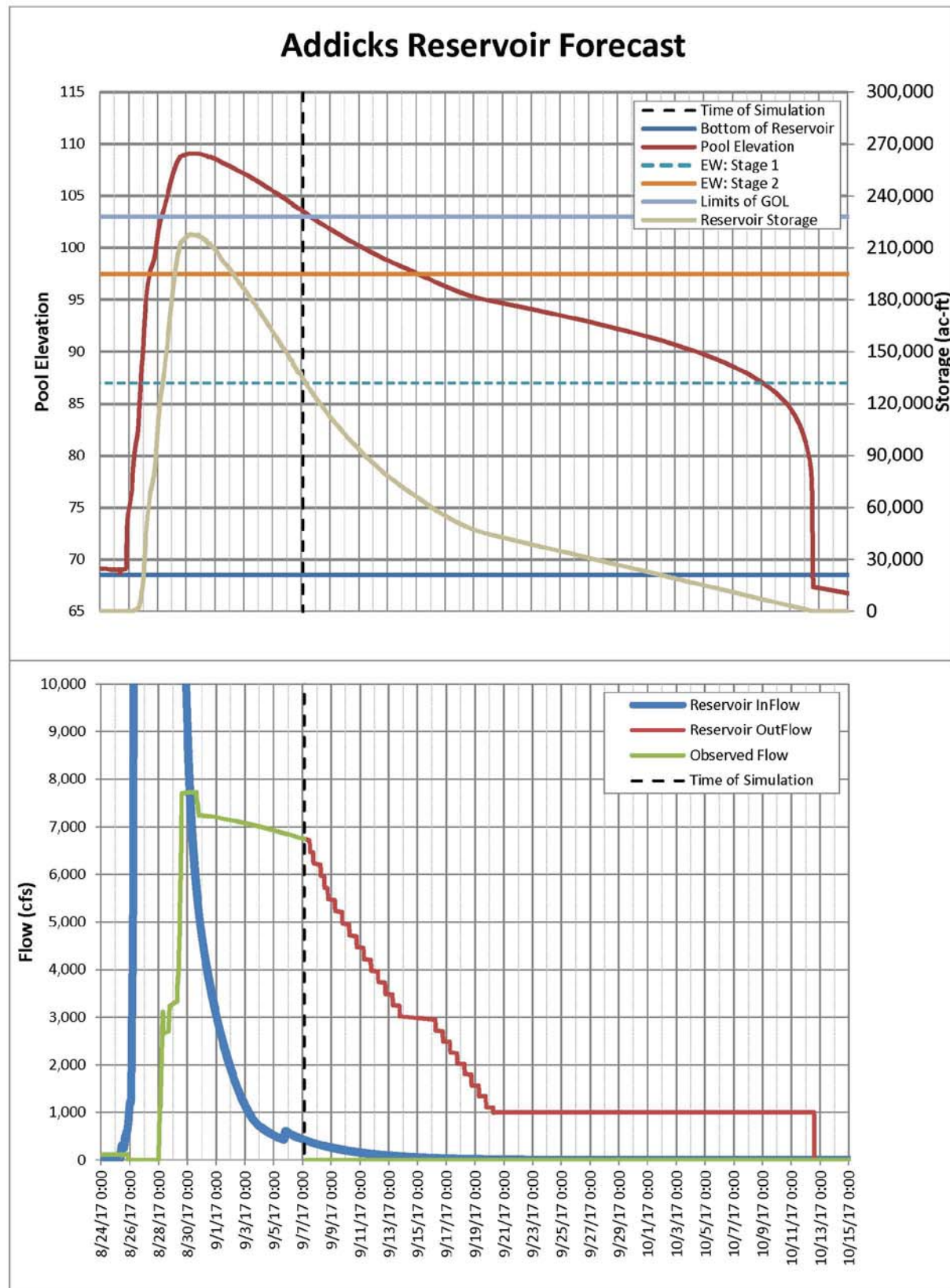
Page 2 of 4

Forecasted on:
7-Sep-17

USACE005938

U.S. Army Corps of Engineers
Galveston District

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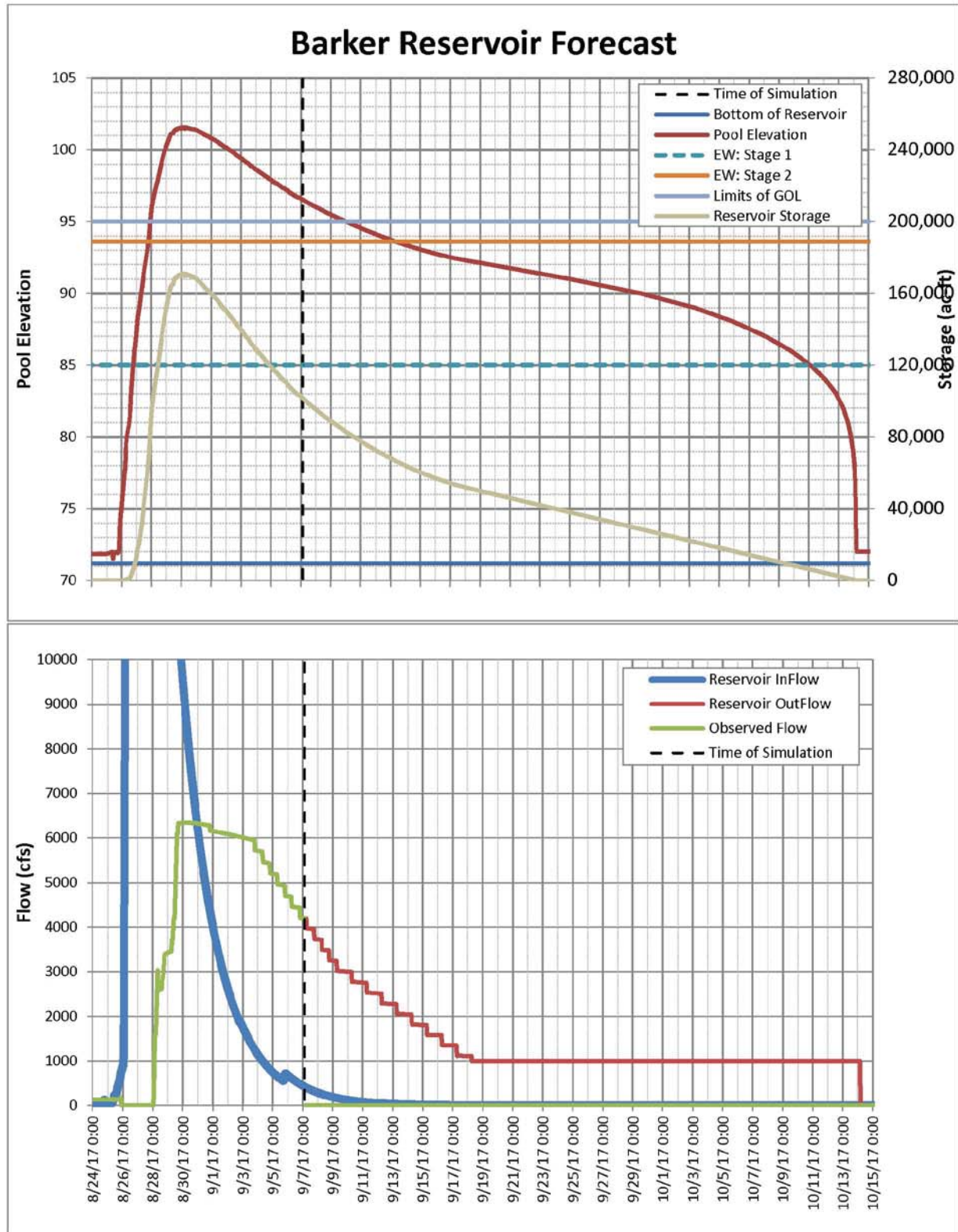
Forecasted by:
M3ODXMGK

Page 3 of 4

Forecasted on:
7-Sep-17

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Galveston District

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CWMS Forecast: 9/8/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 10 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 6200 cfs and Barker is releasing approximately 3700 cfs. The pool in Addicks Reservoir is entirely on government owned land at this time. Releases from Barker Reservoir are no longer overtopping Highway 6. This forecast includes the prospective drawdown on discharges, which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

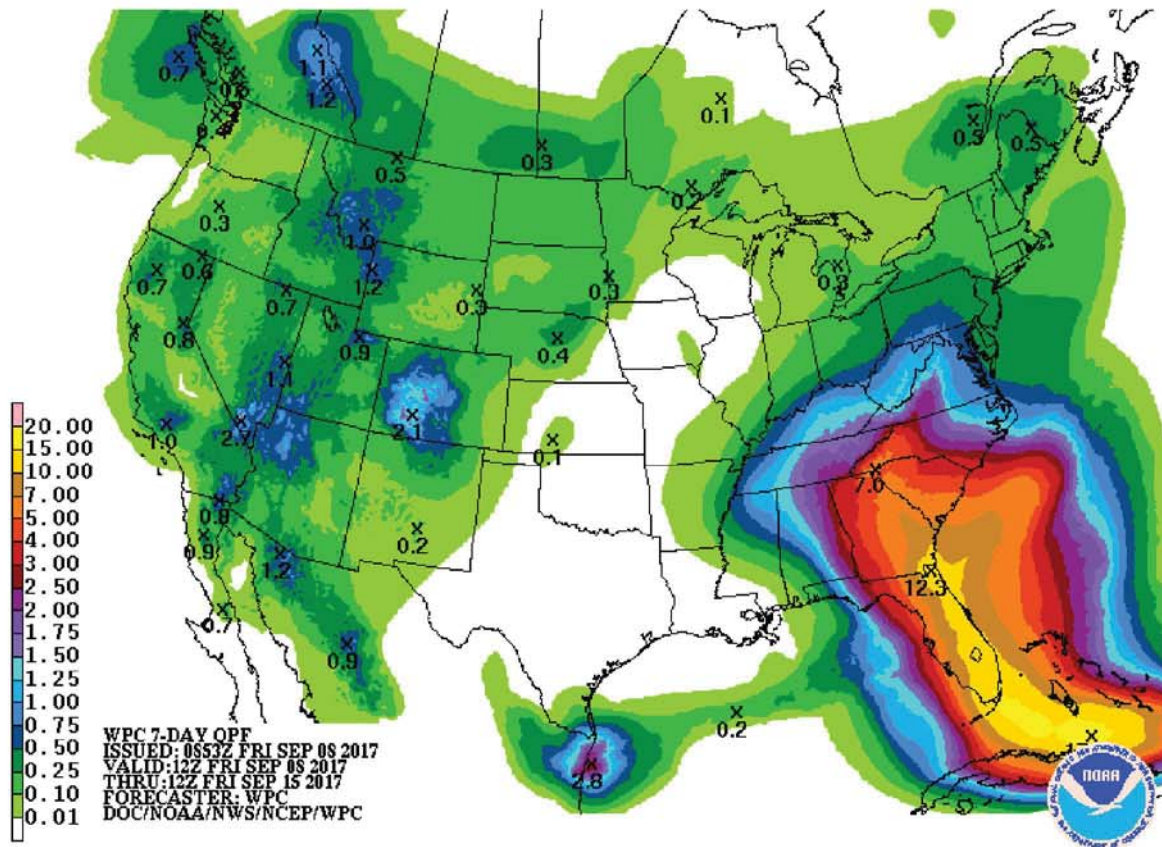
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 9 Sep 2017, 24:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 02:00 | 93.6 | 13 Sep 2017, 8:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/8/2017 02:00
- Lookback Period: 15 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 102.56 ft (NAVD88)
 - Barker: 95.95 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
8-Sep-17

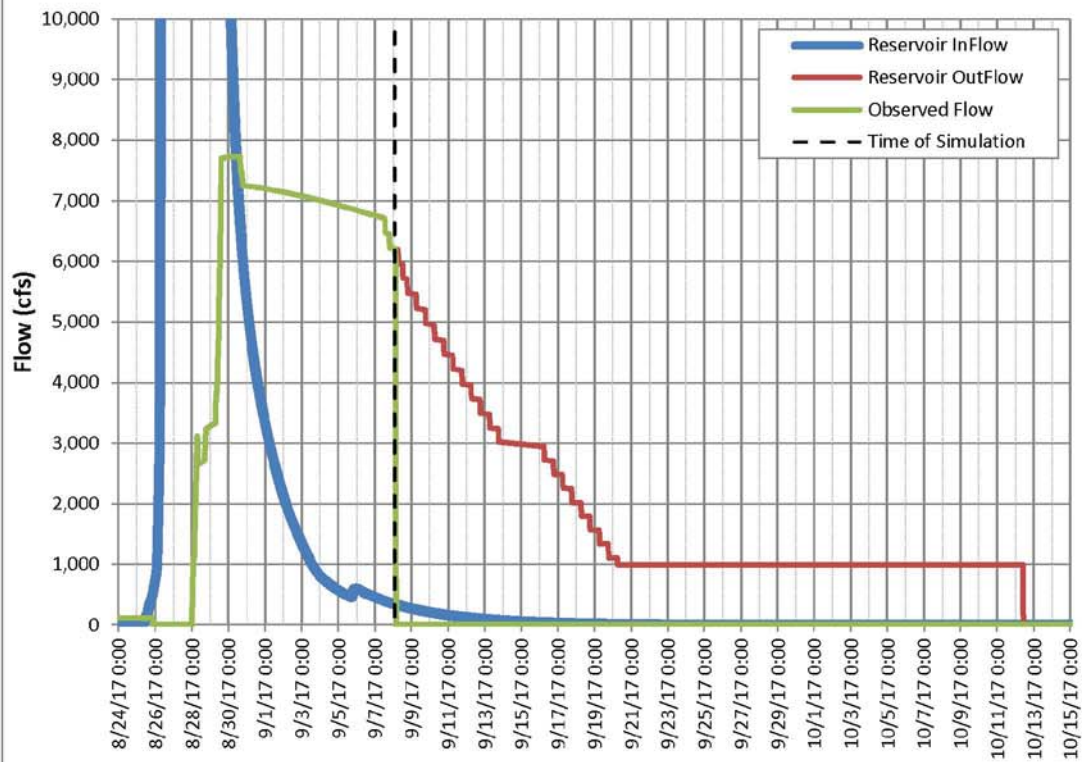
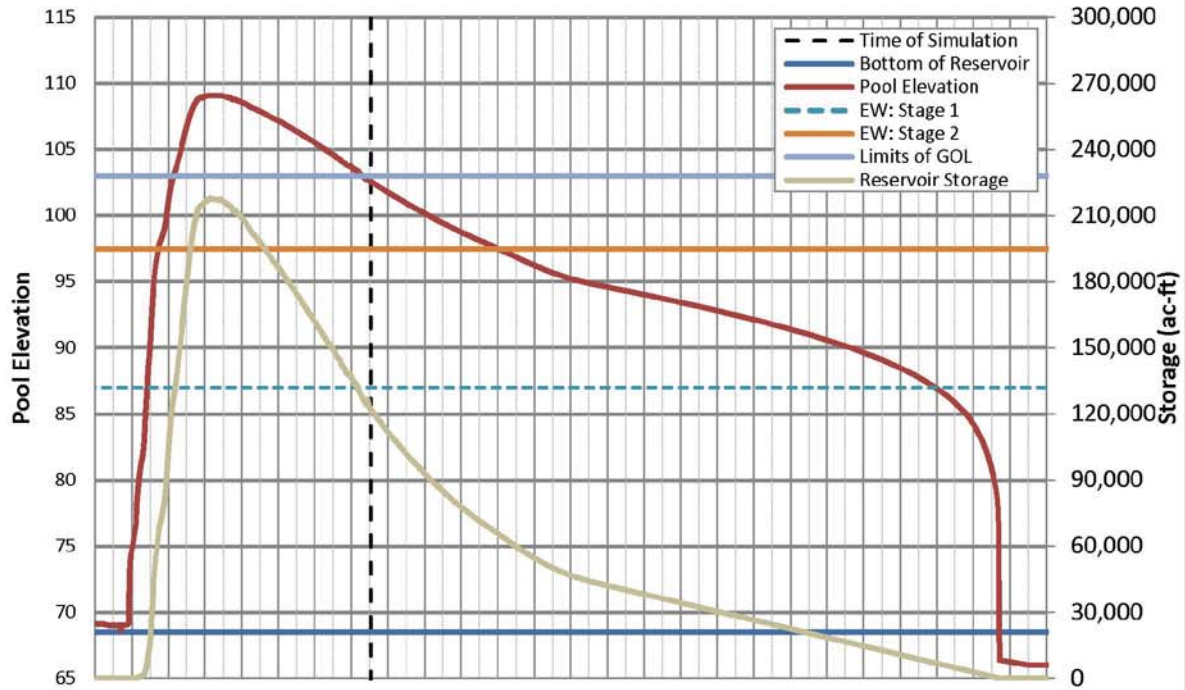
USACE005942

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

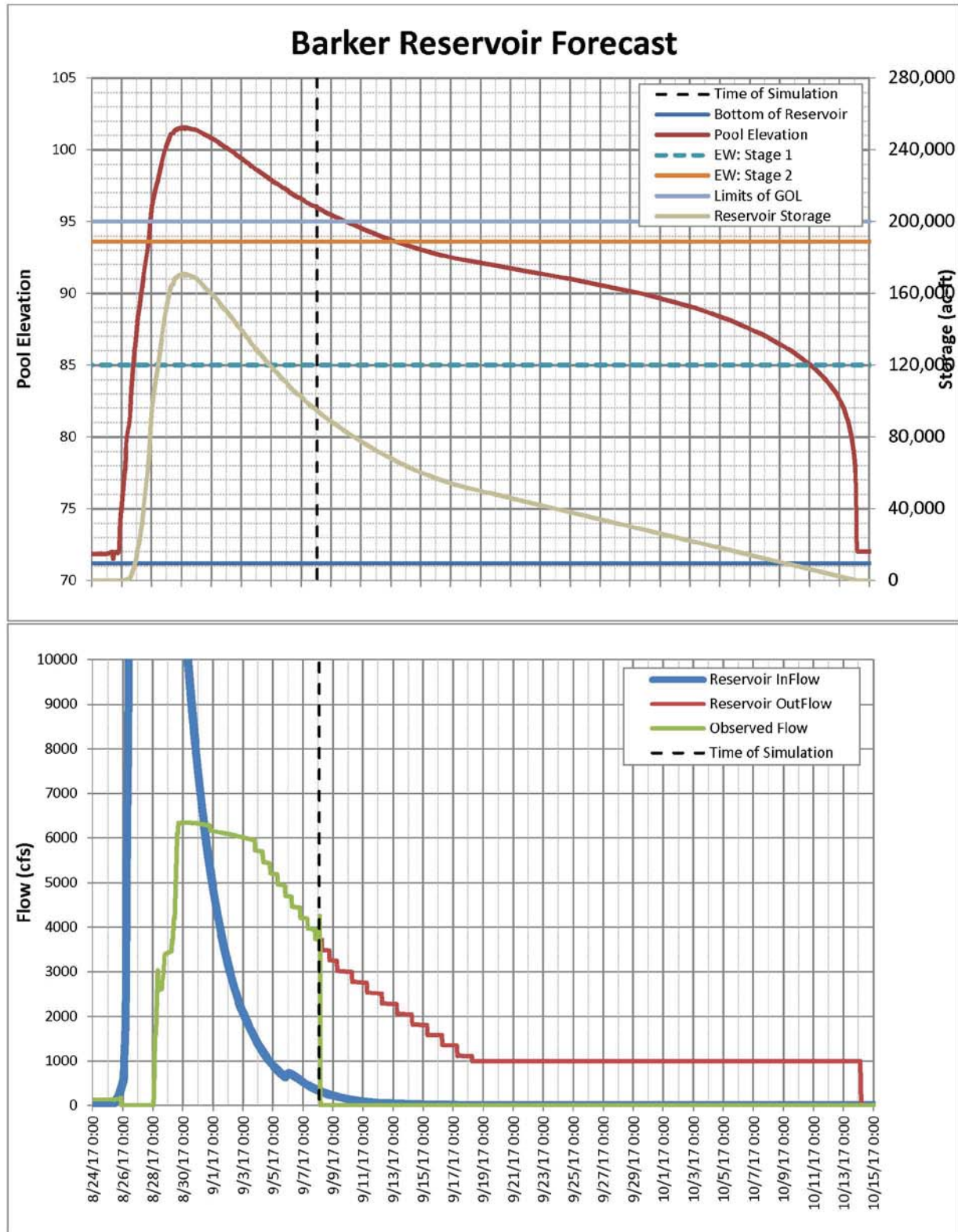
Page 3 of 4

Forecasted on:
8-Sep-17

USACE005943

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/9/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 11 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 5400 cfs and Barker is releasing approximately 3200 cfs. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16. The pools should be off Westheimer by Thursday, Eldridge Parkway by next Saturday, and Highway 6 by next Sunday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

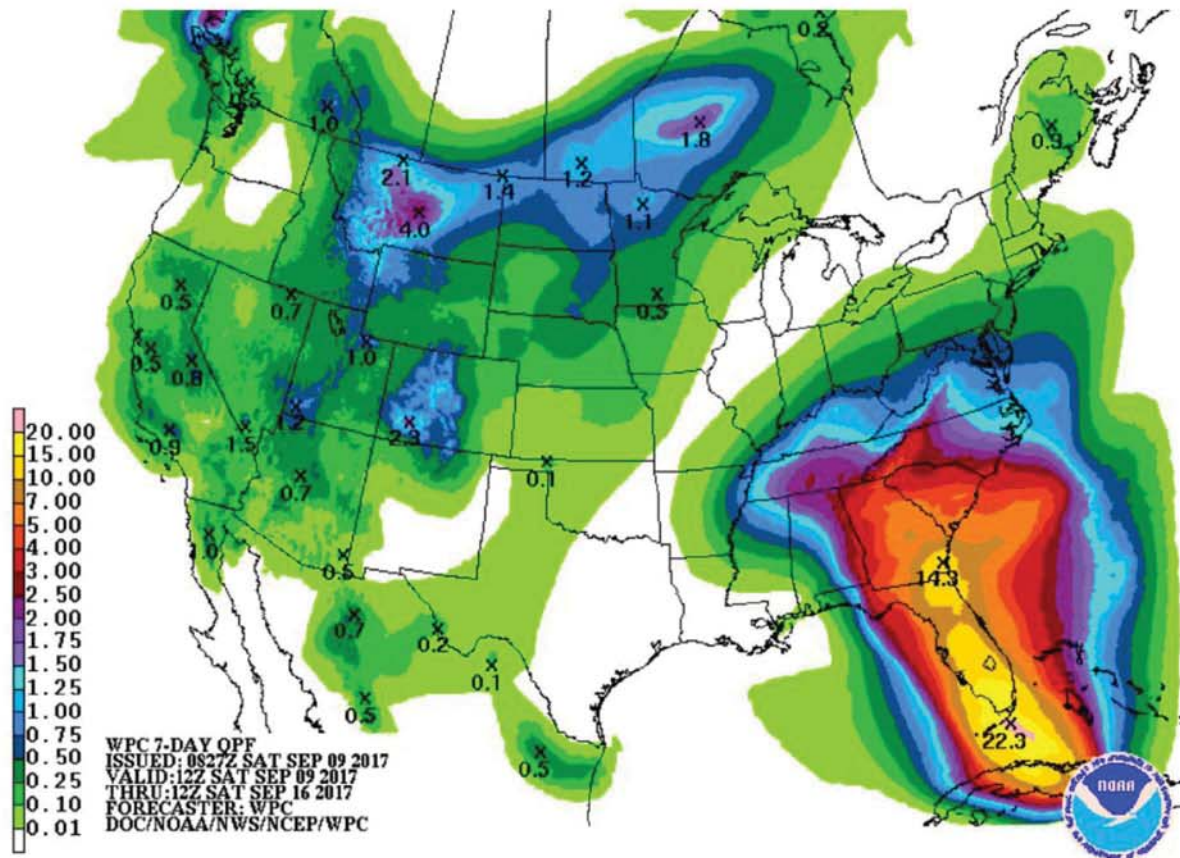
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 02:00 |
| EW, Stage 2 Res. Level | 97.46 | 14 Sep 2017, 23:00 | 93.6 | 13 Sep 2017, 11:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/9/2017 02:00
- Lookback Period: 16 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 101.64 ft (NAVD88)
 - Barker: 95.47 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
9-Sep-17

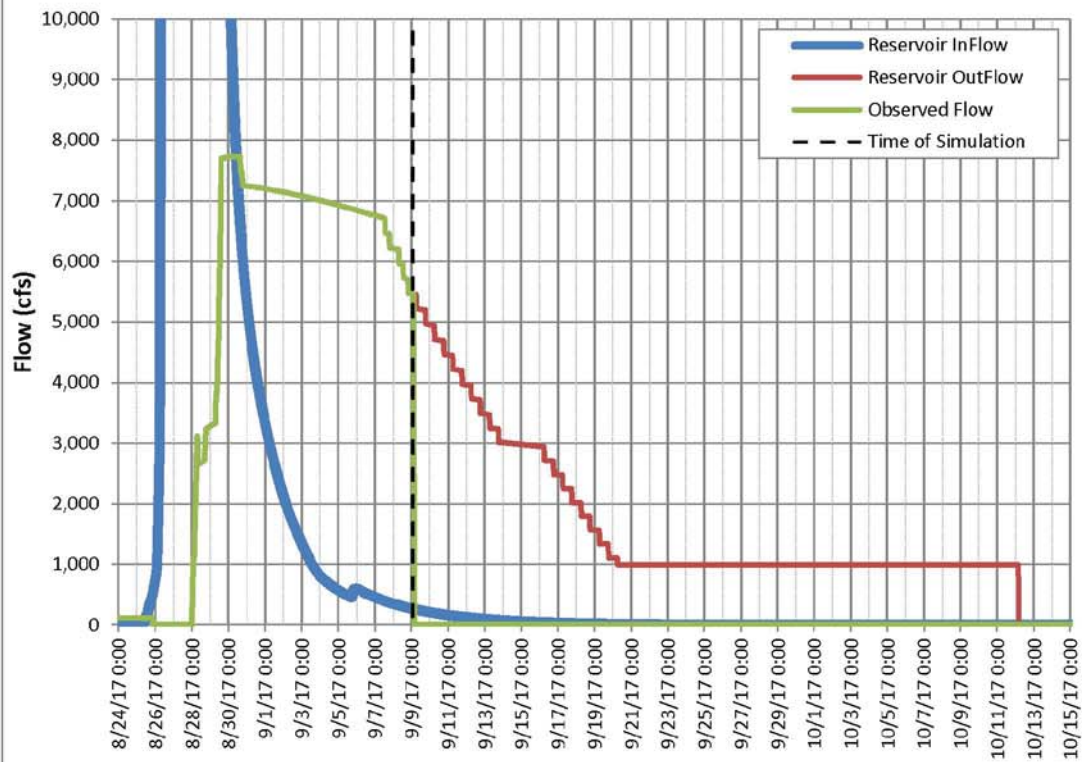
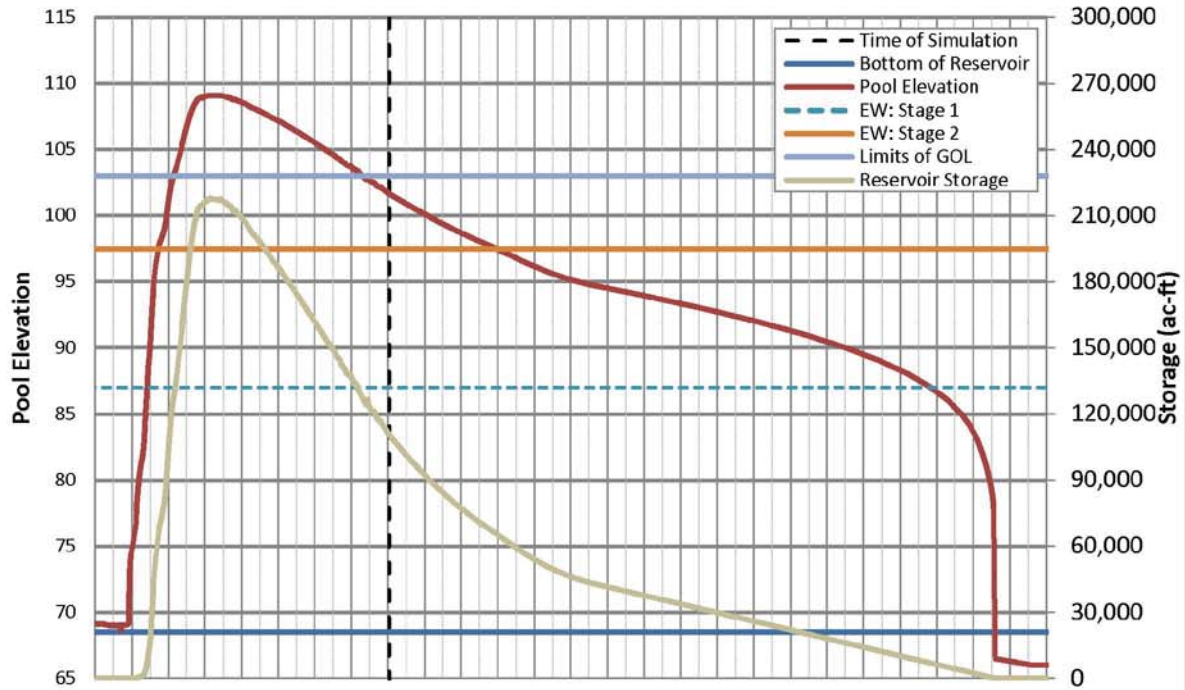
USACE005946

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

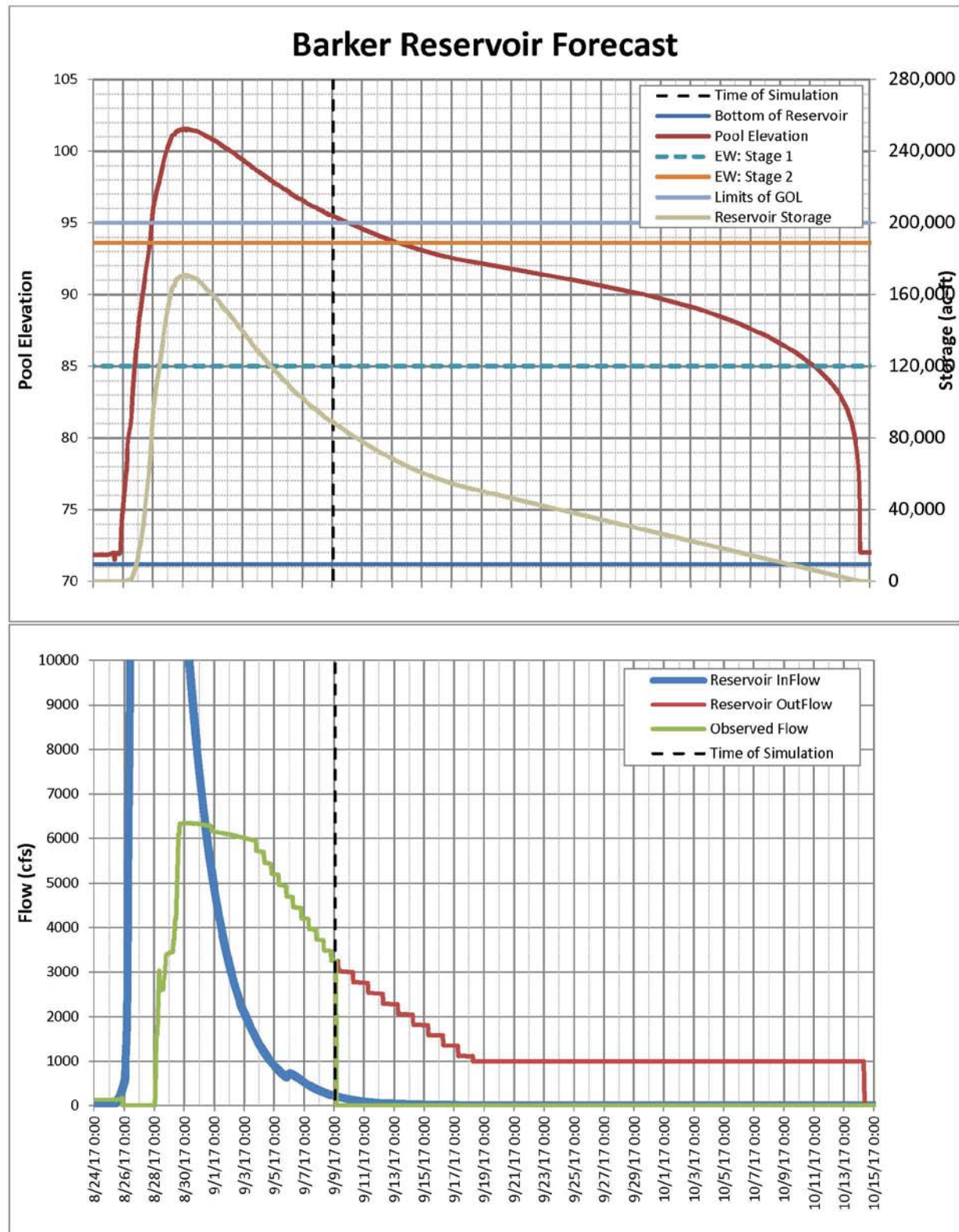
Page 3 of 4

Forecasted on:
9-Sep-17

USACE005947

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/9/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 11 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7 days.

At this time, Addicks is releasing approximately 5400 cfs and Barker is releasing approximately 3200 cfs. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 16. The pools should be off Westheimer by Thursday, Eldridge Parkway by next Saturday, and Highway 6 by next Sunday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

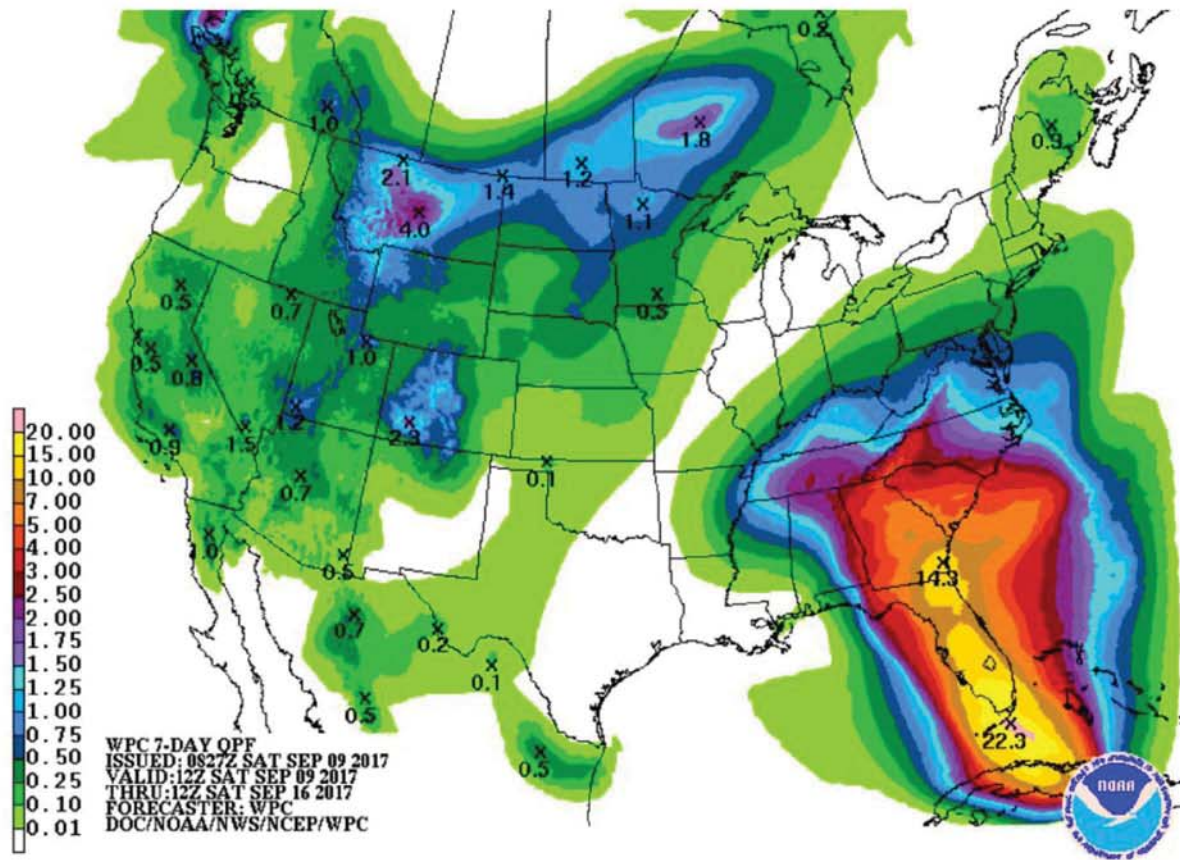
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 02:00 |
| EW, Stage 2 Res. Level | 97.46 | 16 Sep 2017, 04:00 | 93.6 | 13 Sep 2017, 05:00 |
| Empty | 67.5 | 5 - 6 weeks | 70.2 | 5 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/9/2017 09:00
- Lookback Period: 16 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 101.36 ft (NAVD88)
 - Barker: 95.35 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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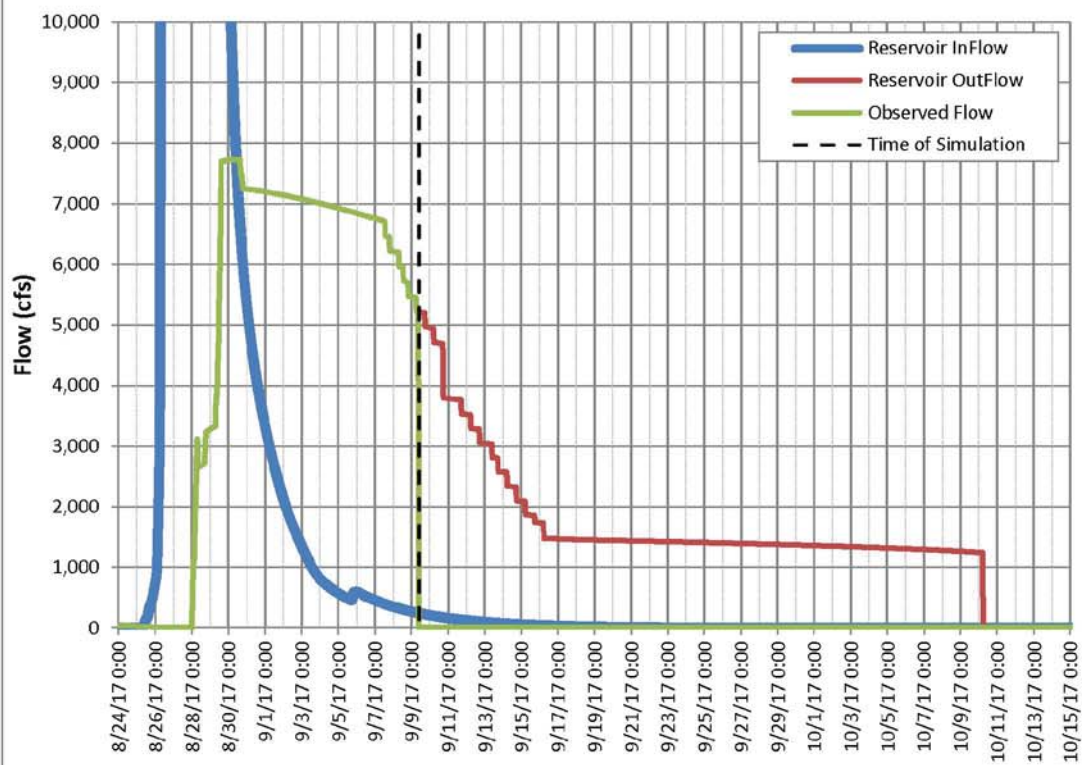
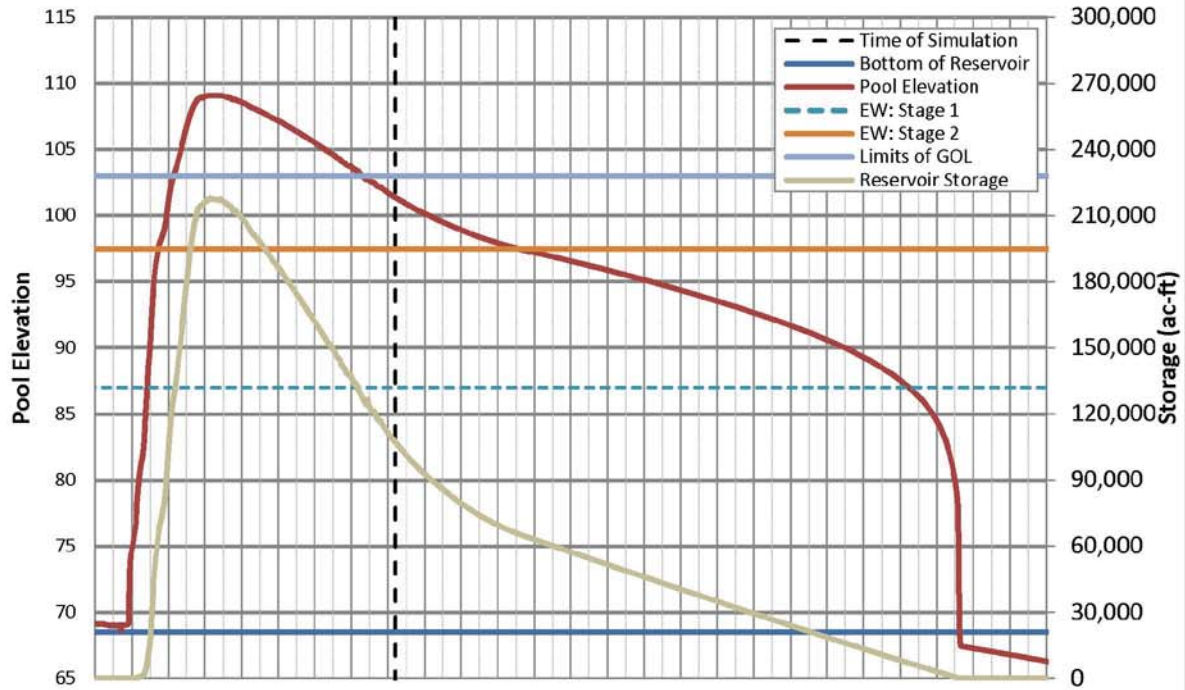
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

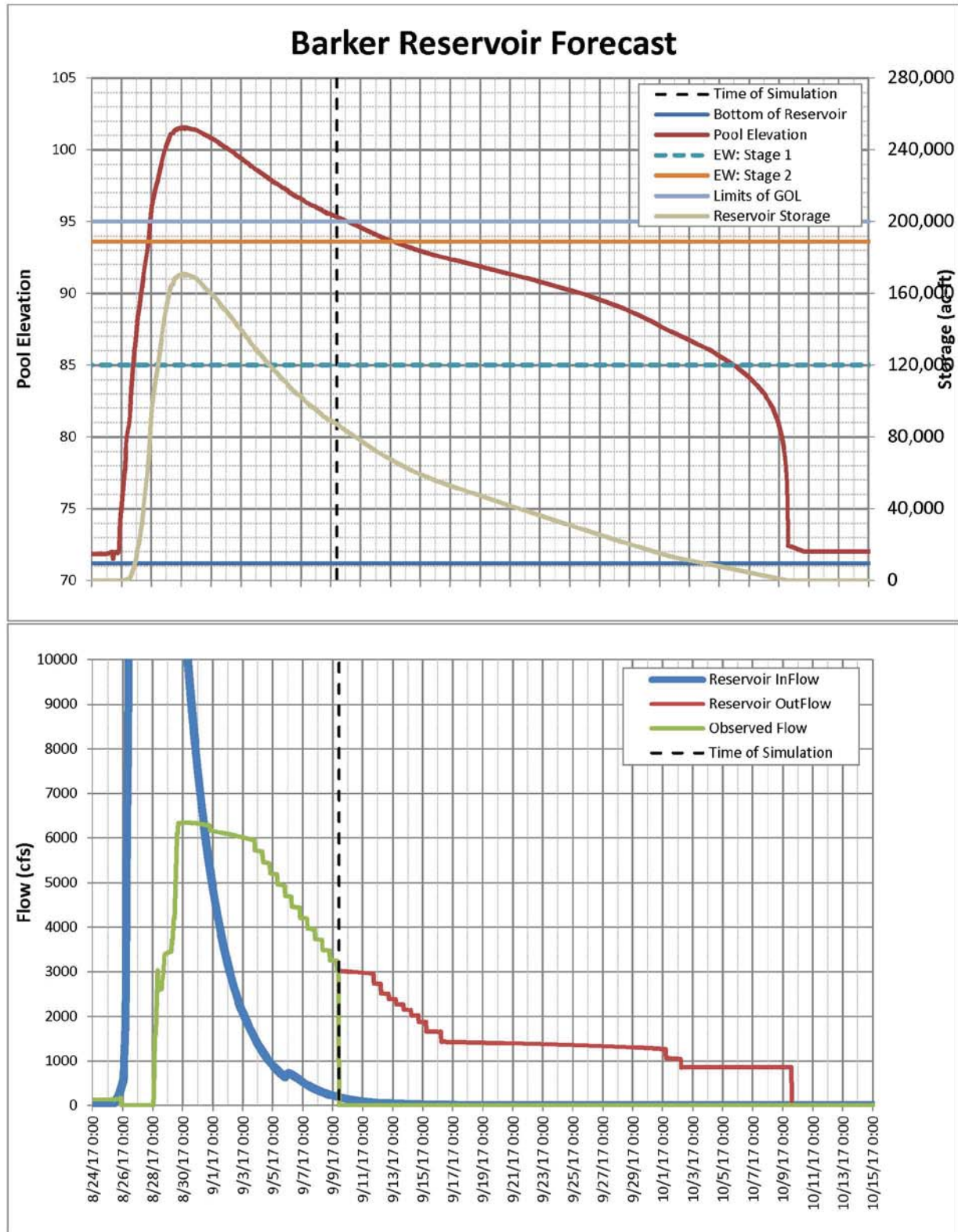
Page 3 of 4

Forecasted on:
9-Sep-17

USACE005951

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/10/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 12 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 4900 cfs and Barker is releasing approximately 3000 cfs. The pool in both reservoirs is now fully confined to government owned land. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15. The pools should be off Westheimer by Thursday and off Eldridge Parkway in 8-10 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

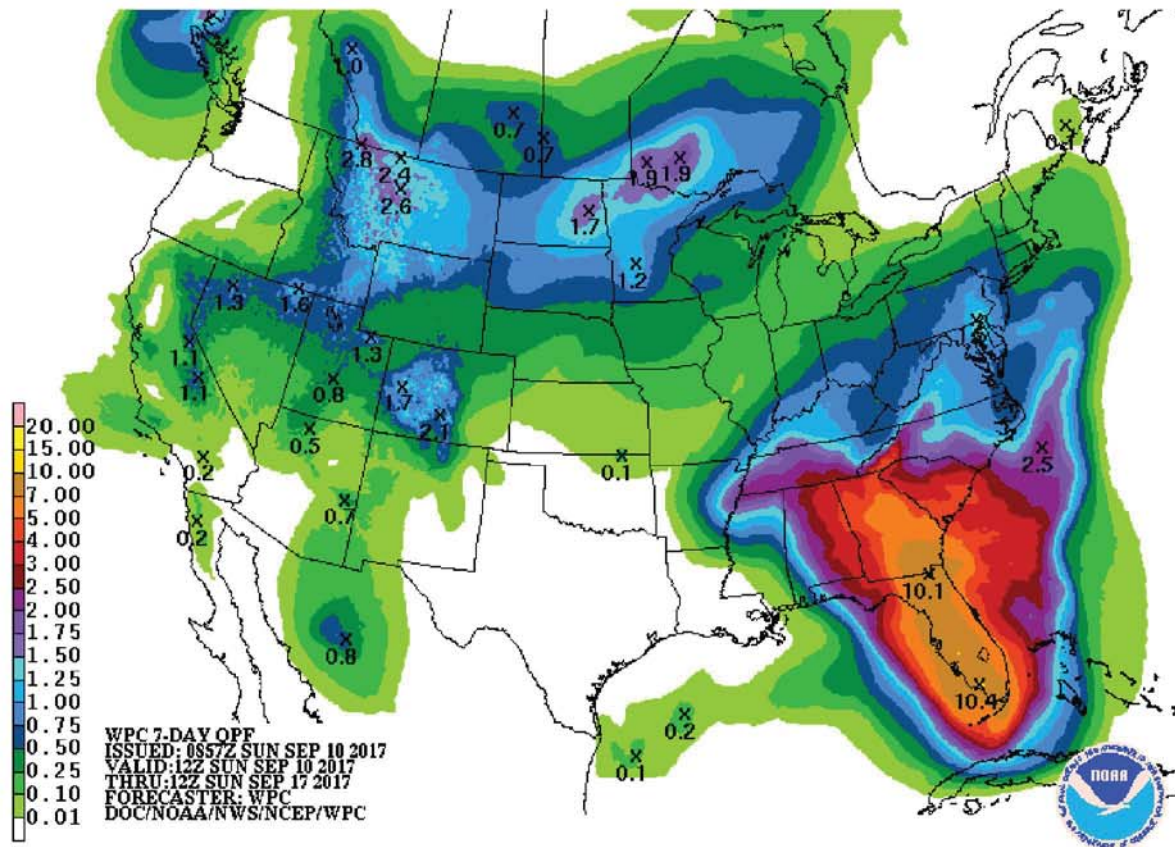
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 17:00 | 93.6 | 13 Sep 2017, 05:00 |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/10/2017 03:00
- Lookback Period: 17 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 100.70 ft (NAVD88)
 - Barker: 95.00 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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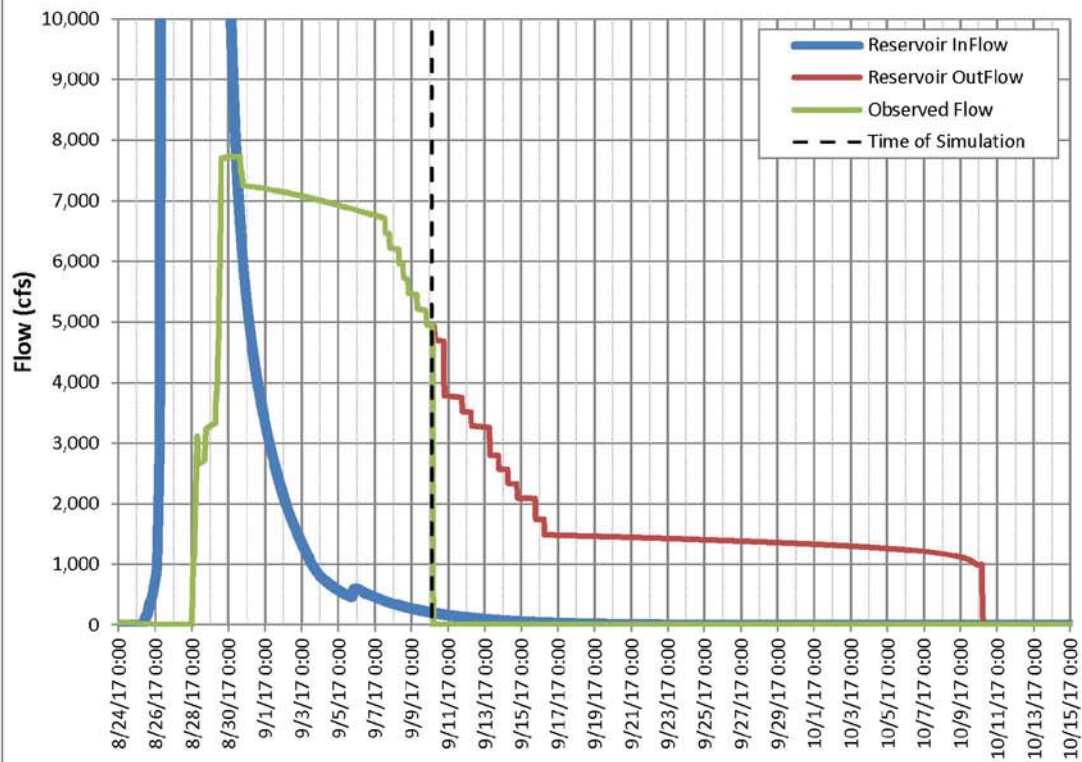
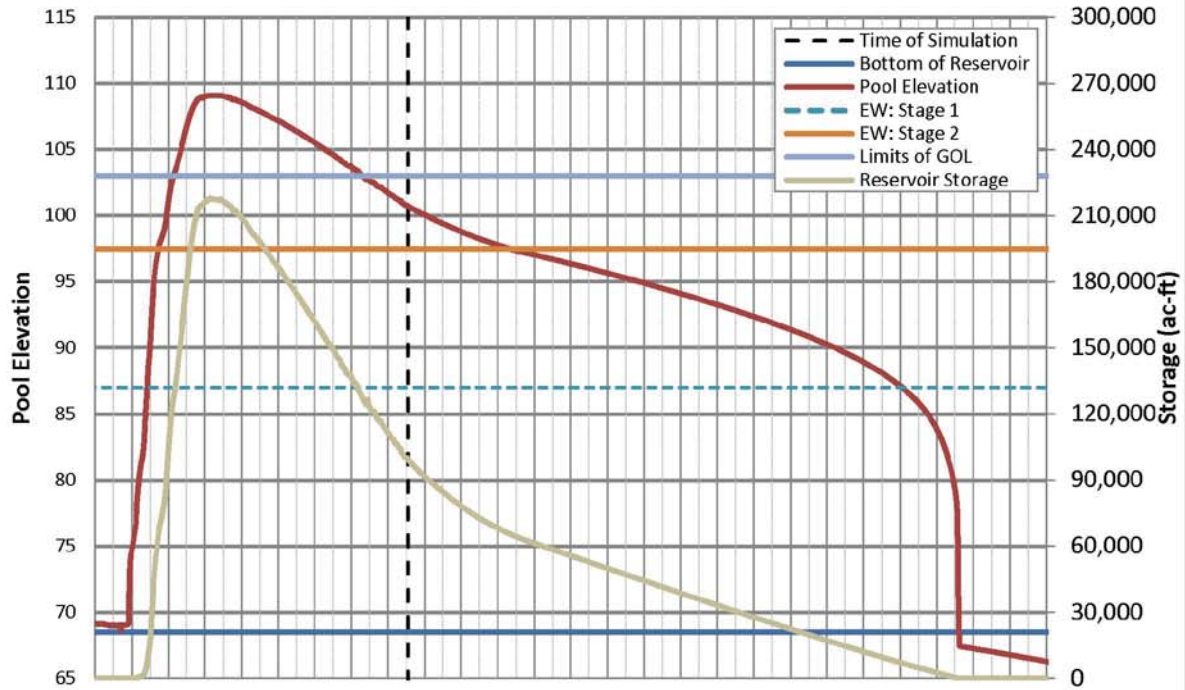
7-day QPF

U.S. Army Corps of Engineers
Galveston District

DRAFT



Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

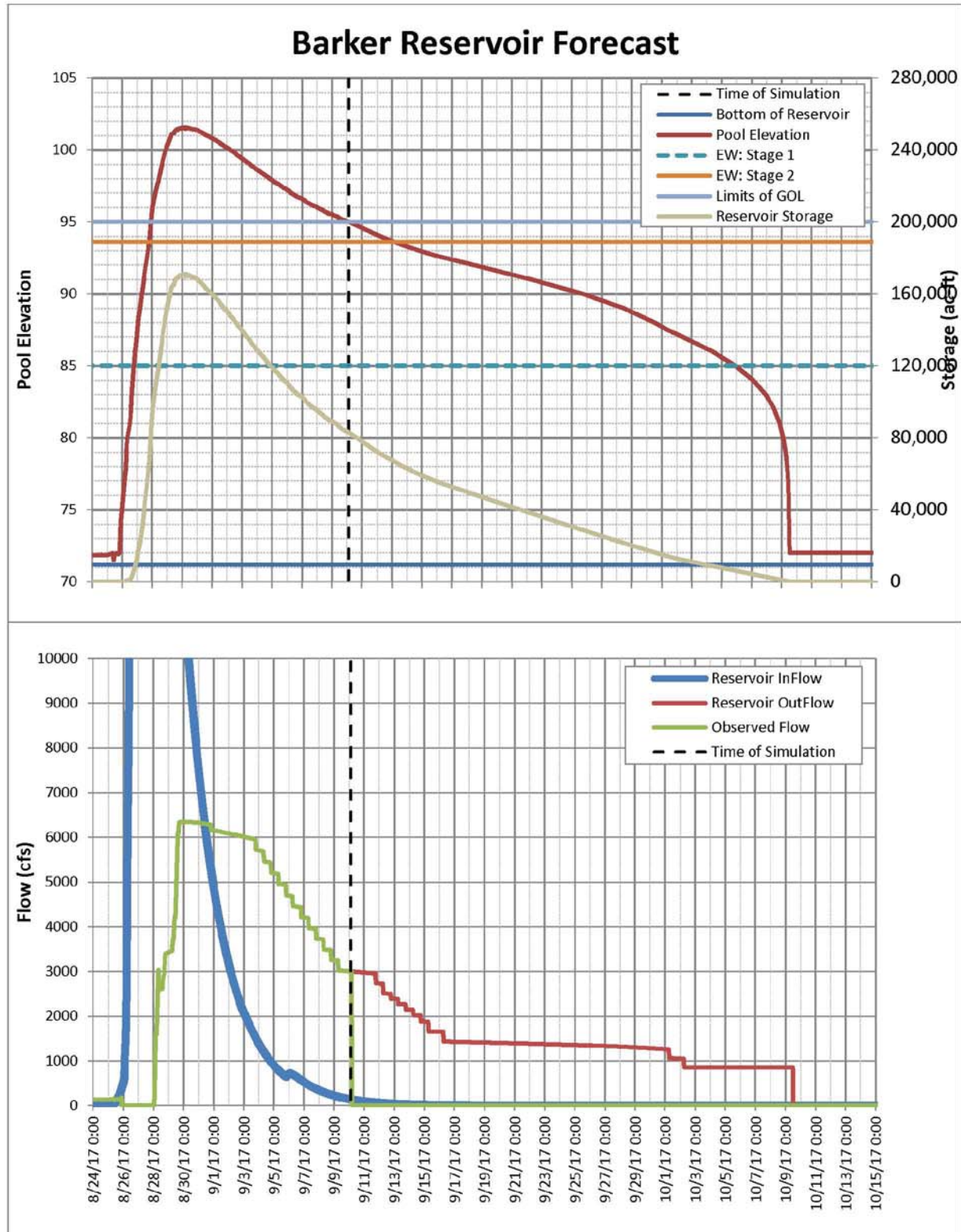
Page 3 of 4

Forecasted on:
10-Sep-17

USACE005955

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/11/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 13 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 3770 cfs and Barker is releasing approximately 2970 cfs. This forecast includes the planned drawdown of discharges that is being enacted to minimize damage to the banks of the bayou. With these assumed discharge rates and no further rain, flows in Buffalo Bayou will be below 4000 cfs by Thursday, September 14. The pools should be off Westheimer Parkway by Thursday and off Eldridge Parkway and Highway 6 in 7 – 9 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

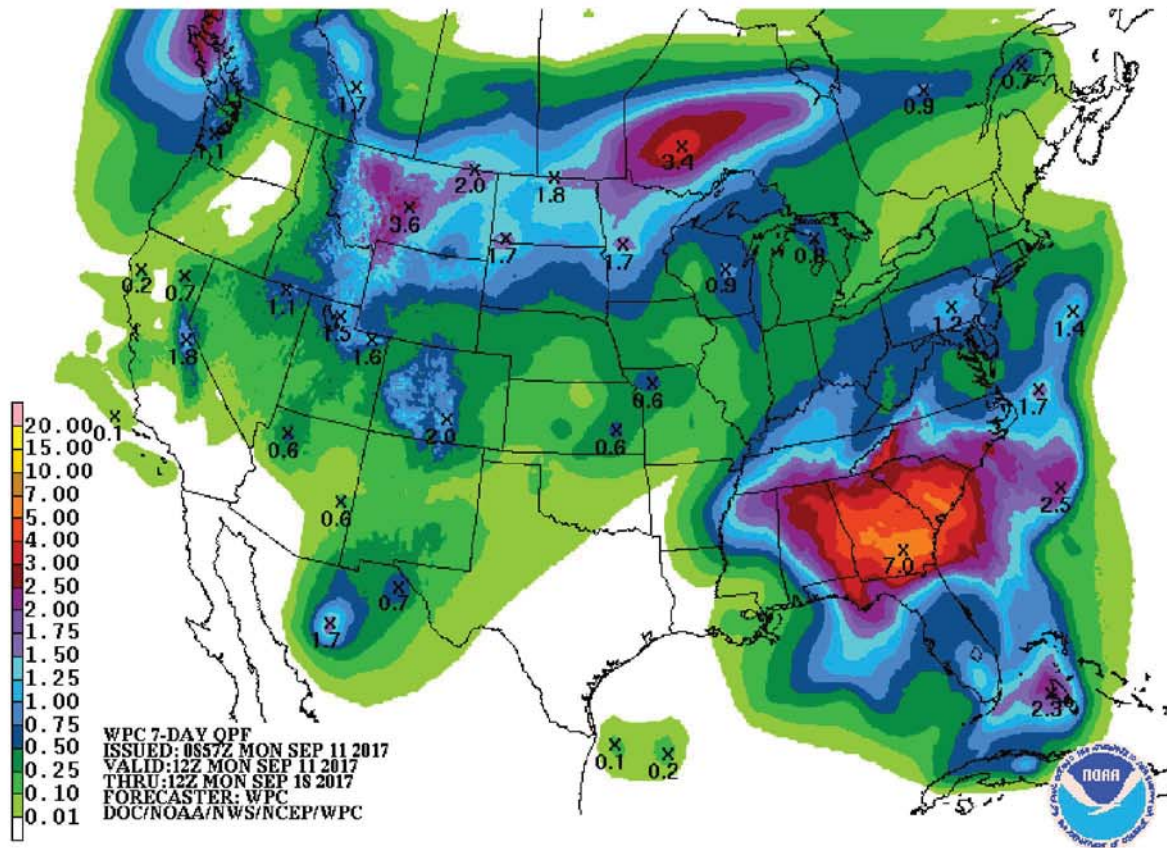
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 15:00 | 93.6 | 13 Sep 2017, 06:00 |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/11/2017 02:00
- Lookback Period: 18 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 99.94 ft (NAVD88)
 - Barker: 94.56 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

DRAFT



7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
11-Sep-17

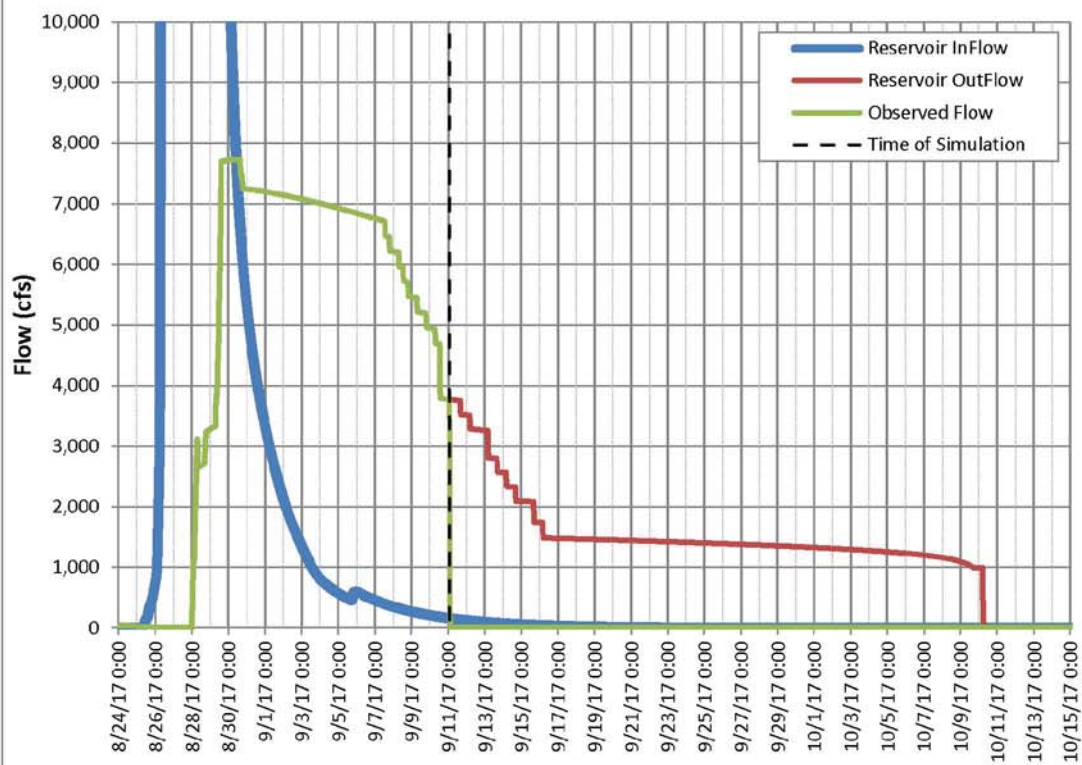
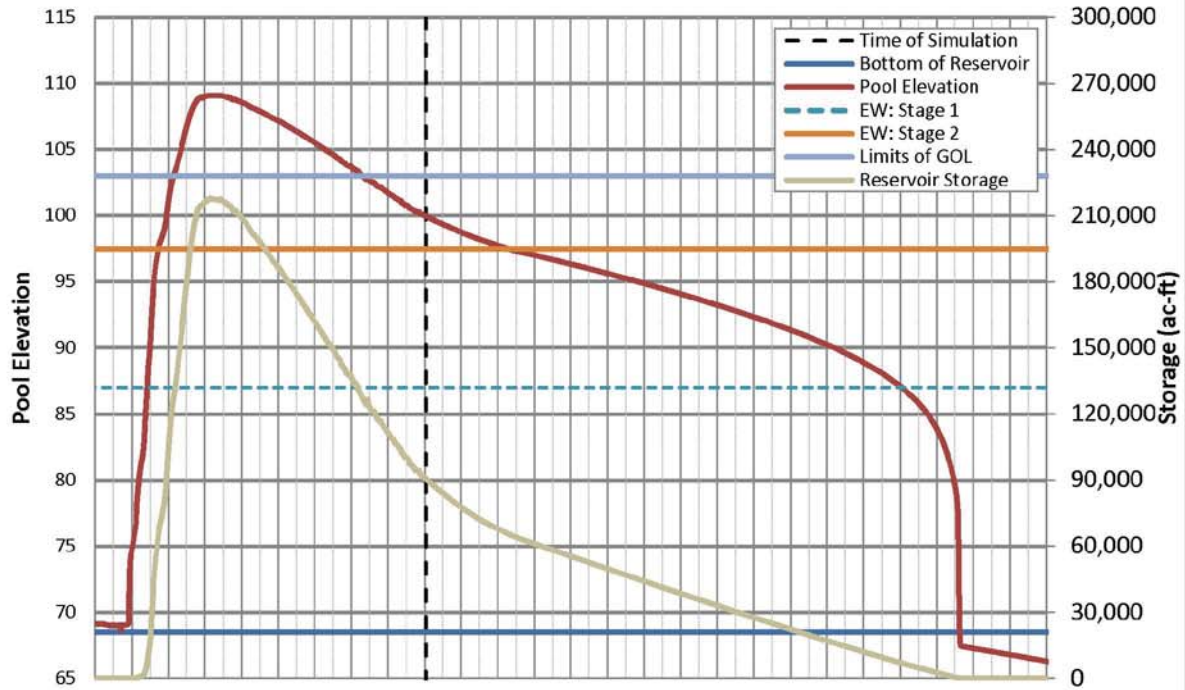
USACE005958

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

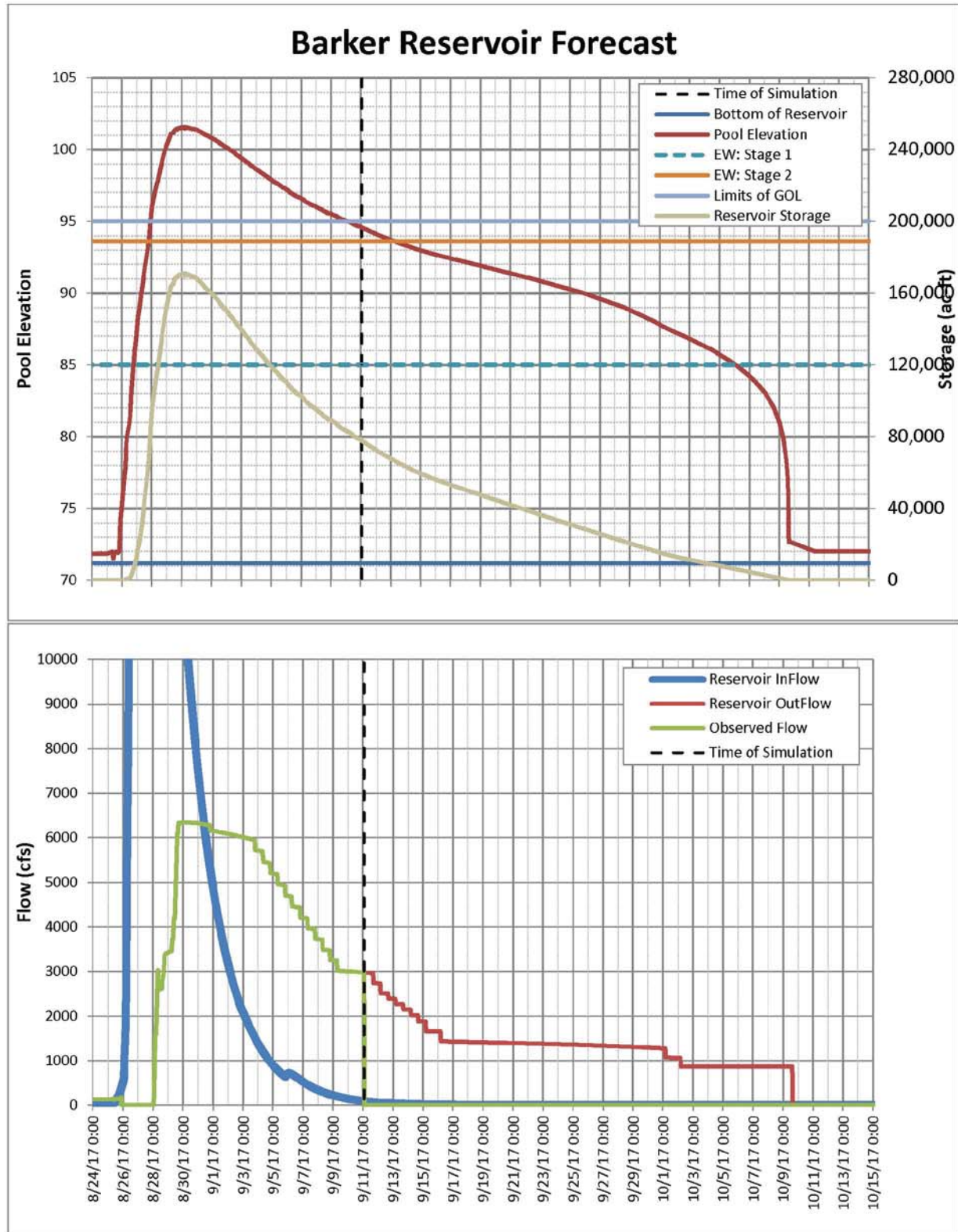
Page 3 of 4

Forecasted on:
11-Sep-17

USACE005959

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/12/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 14 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is no rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 3,500 cfs and Barker is releasing approximately 2,700 cfs. The pool in both reservoirs is now fully confined to government owned land. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15. The pools should be off Westheimer by Thursday and off Eldridge Parkway in 6-8 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

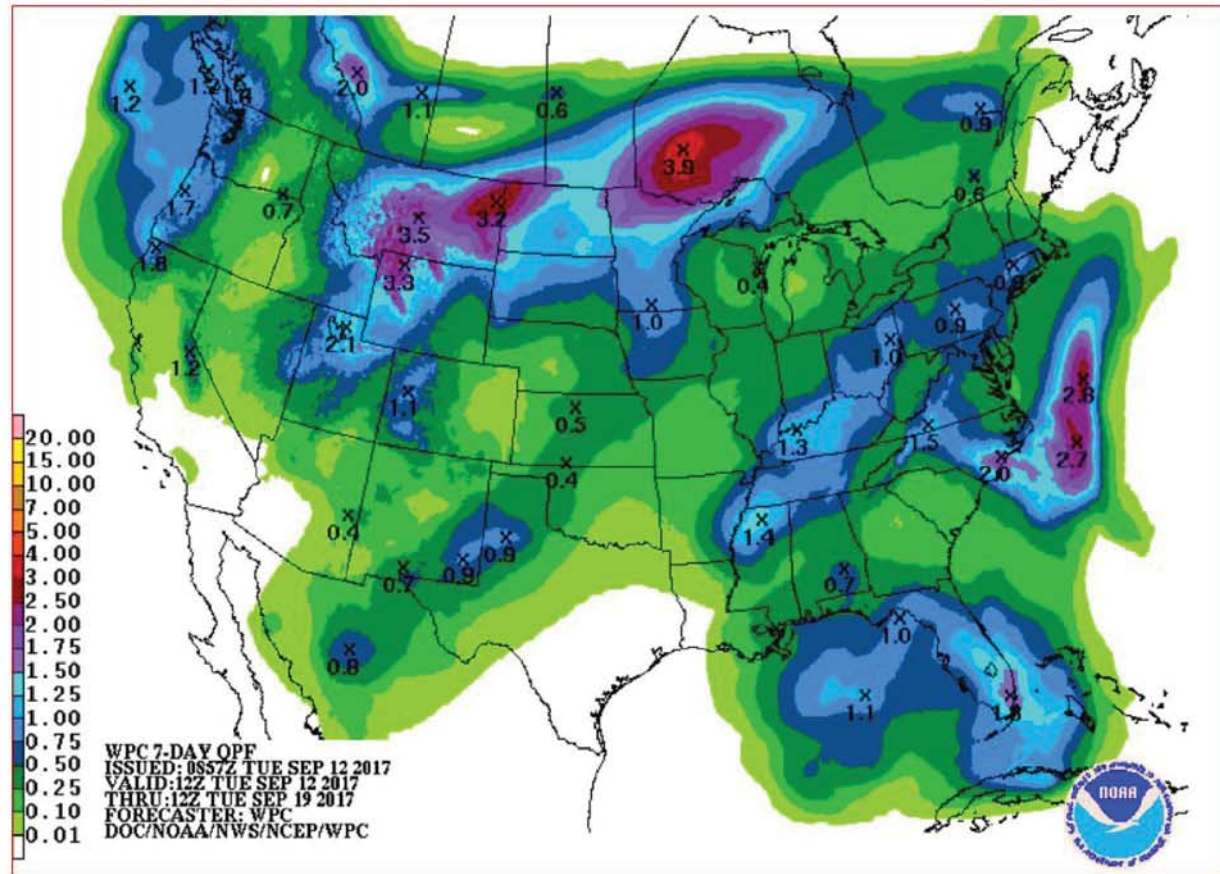
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 17:00 | 93.6 | 13 Sep 2017, 05:00 |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/12/2017 04:00
- Lookback Period: 19 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 99.33 ft (NAVD88)
 - Barker: 94.08 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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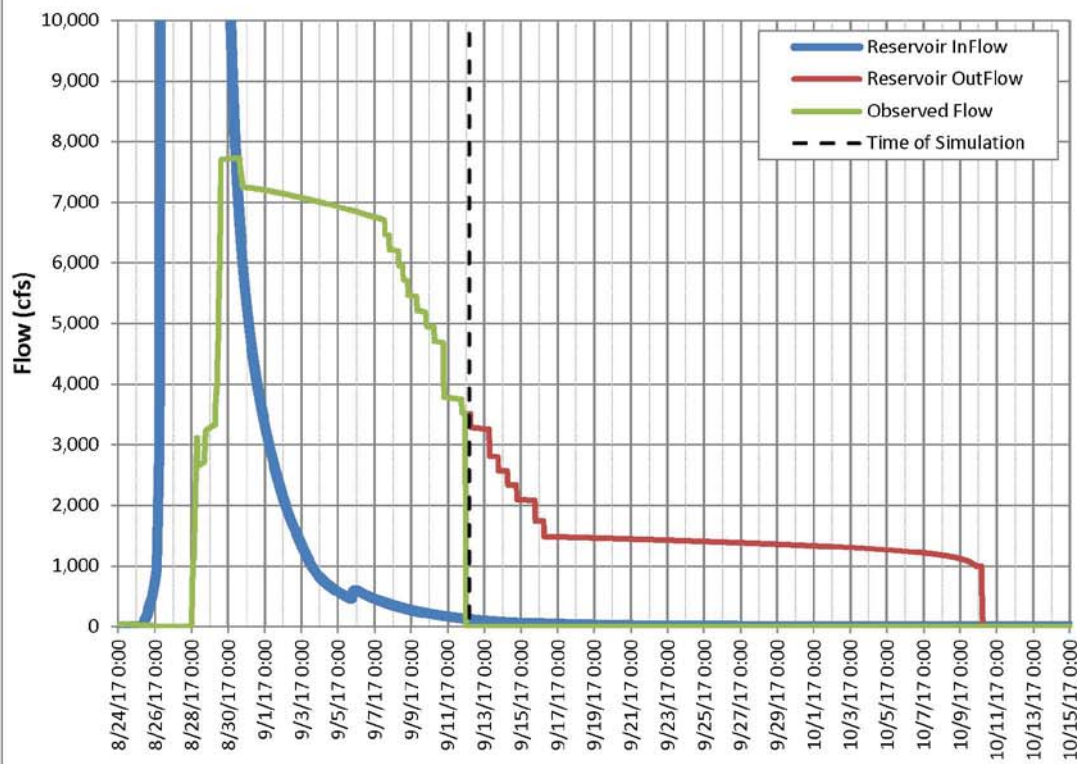
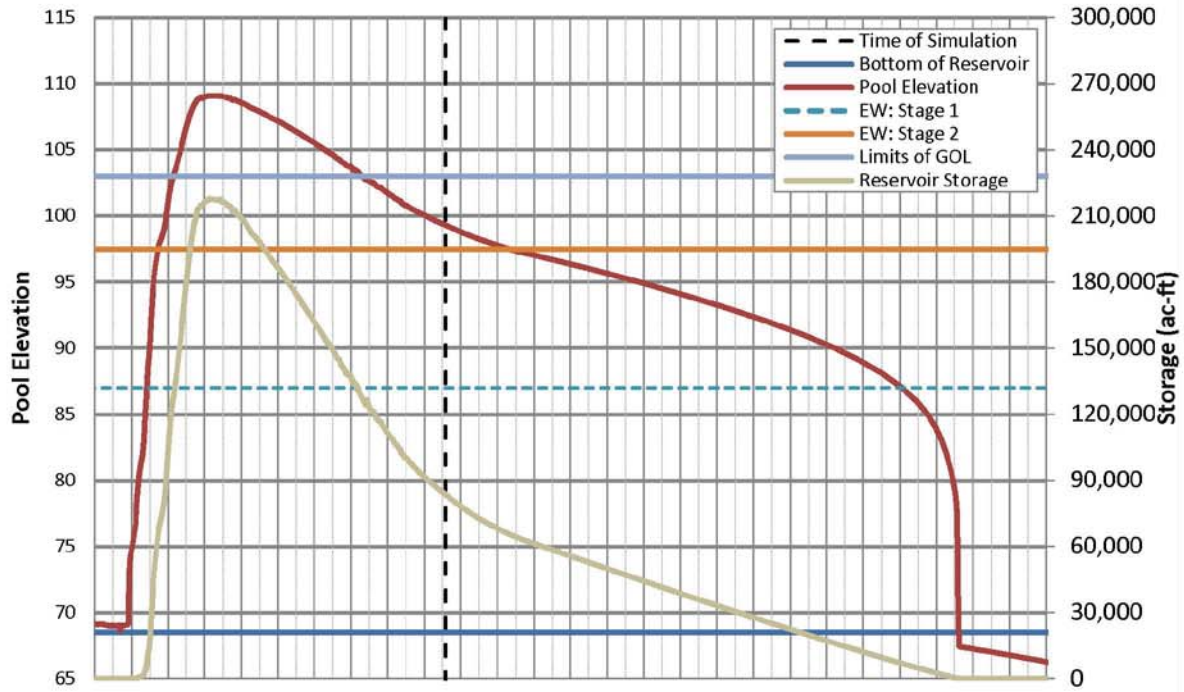
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

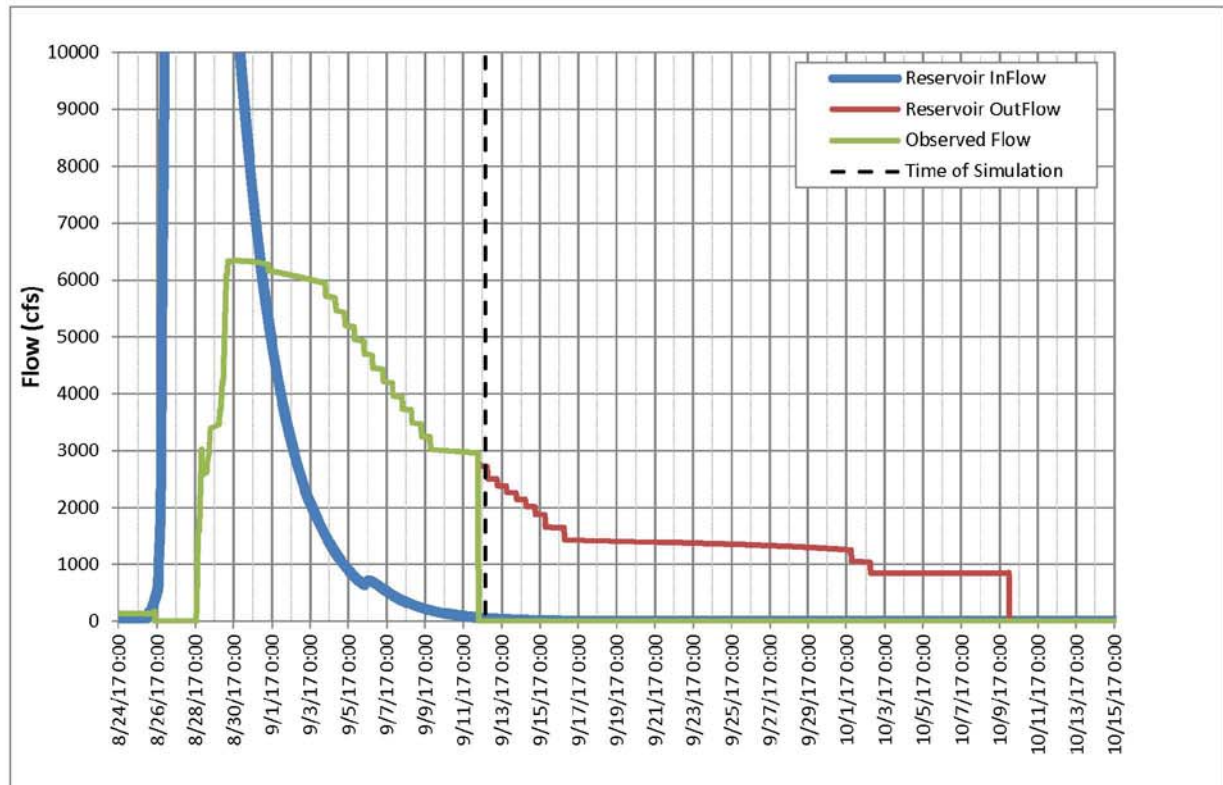
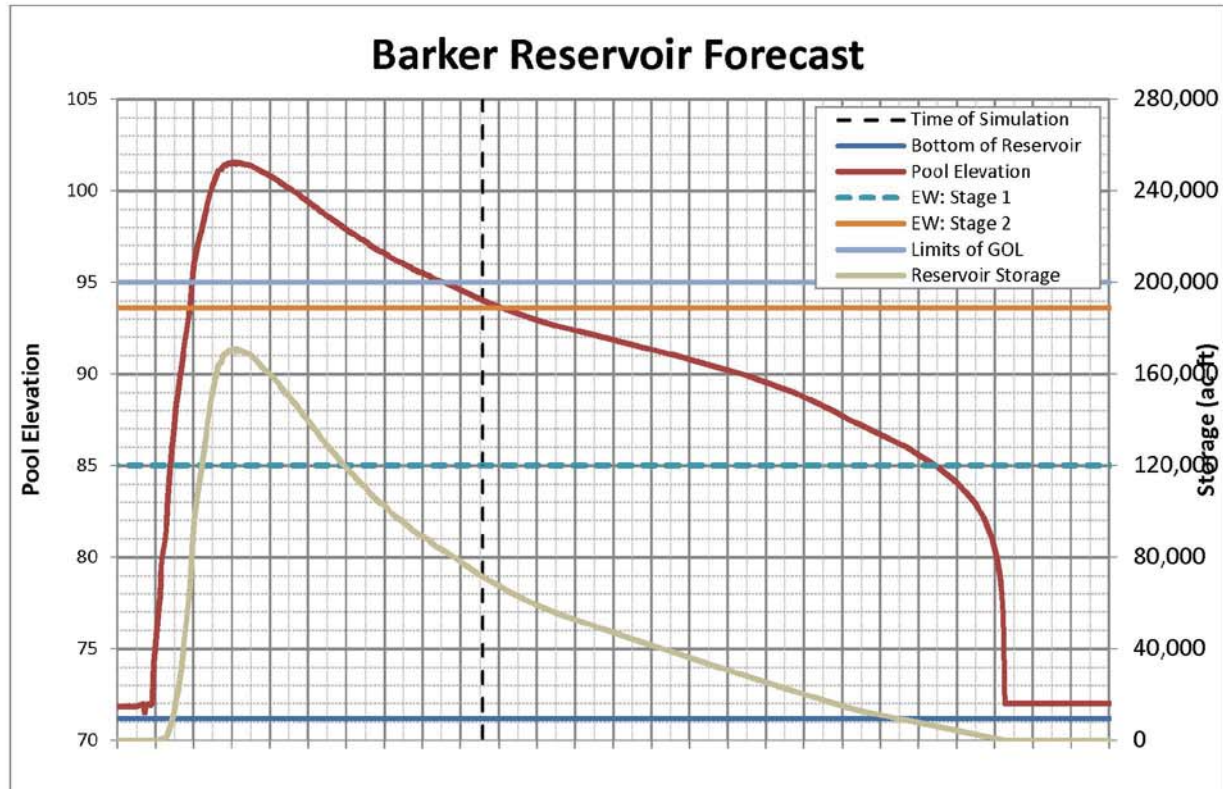
Page 3 of 4

Forecasted on:
12-Sep-17

USACE005963

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/13/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 15 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is about 0.3" of rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 3,300 cfs and Barker is releasing approximately 2,400 cfs. The pool in both reservoirs is now fully confined to government owned land. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by September 15. The pools should be off Westheimer by tomorrow and off Eldridge Parkway and Hwy 6 in 5-7 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

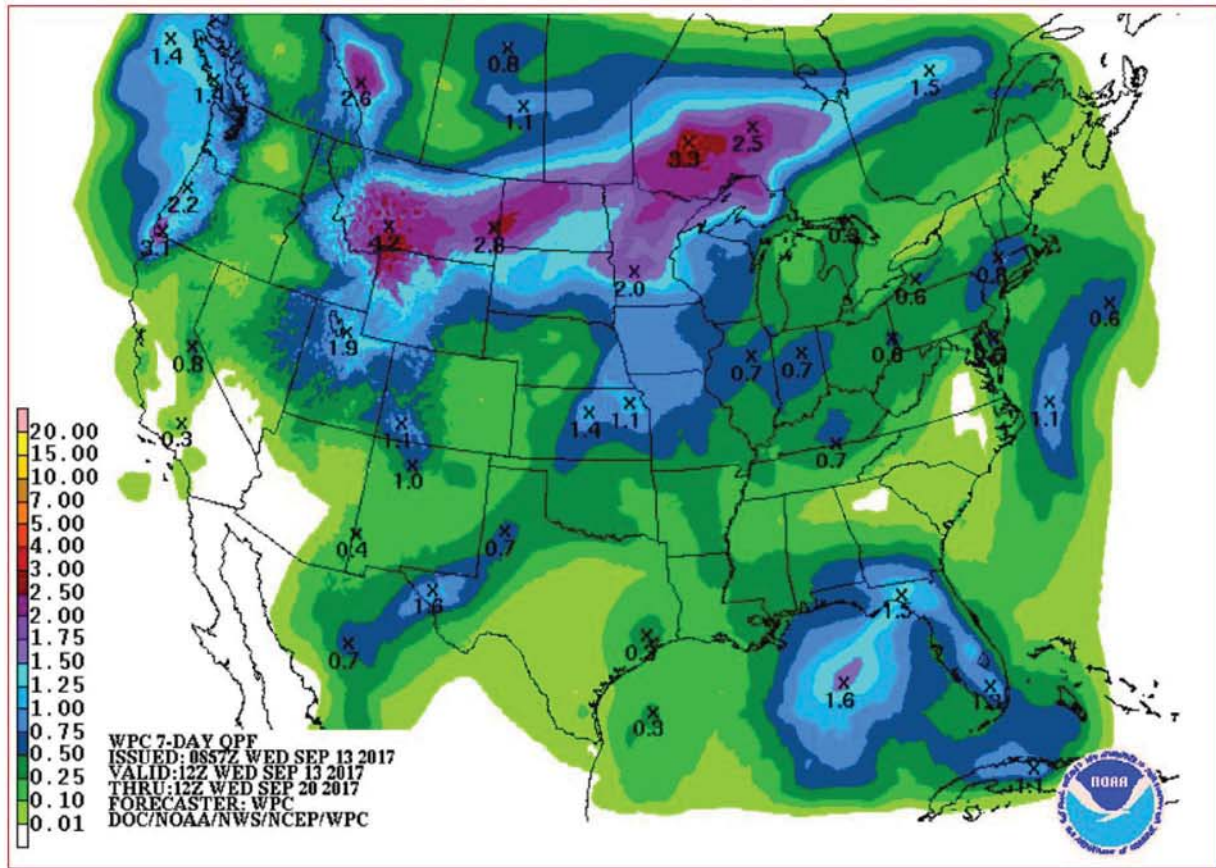
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 17:00 | 93.6 | 13 Sep 2017, 05:00 |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/13/2017 04:00
- Lookback Period: 19 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 98.71 ft (NAVD88)
 - Barker: 93.7 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
13-Sep-17

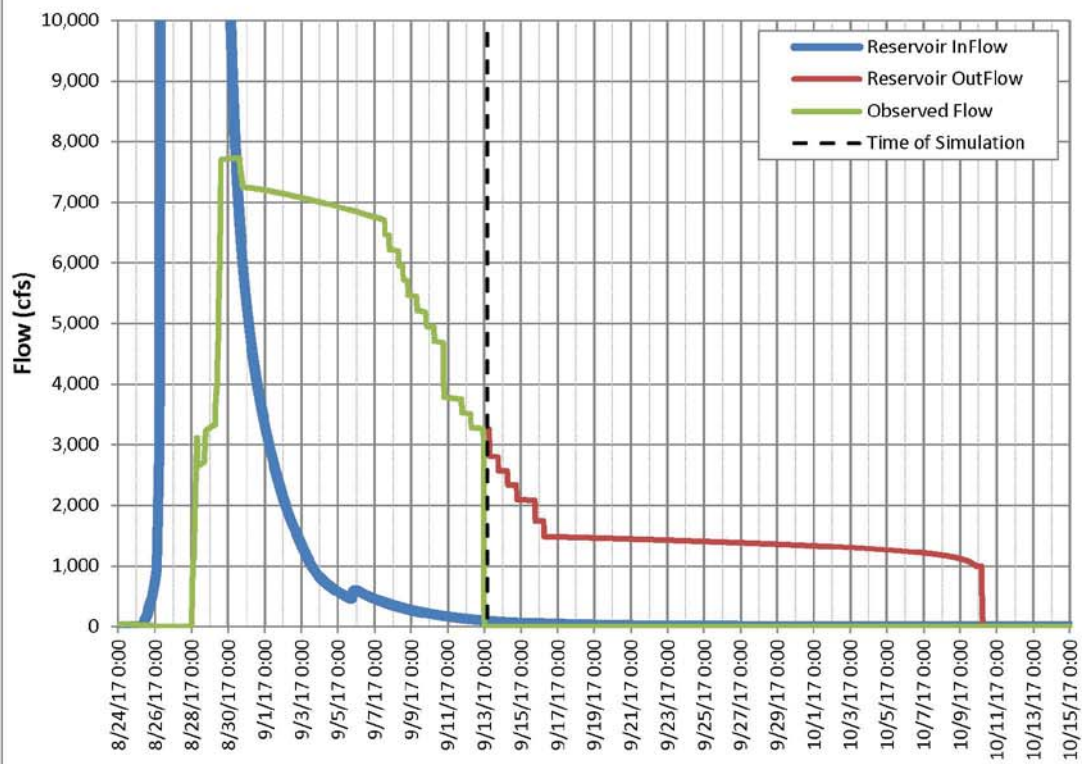
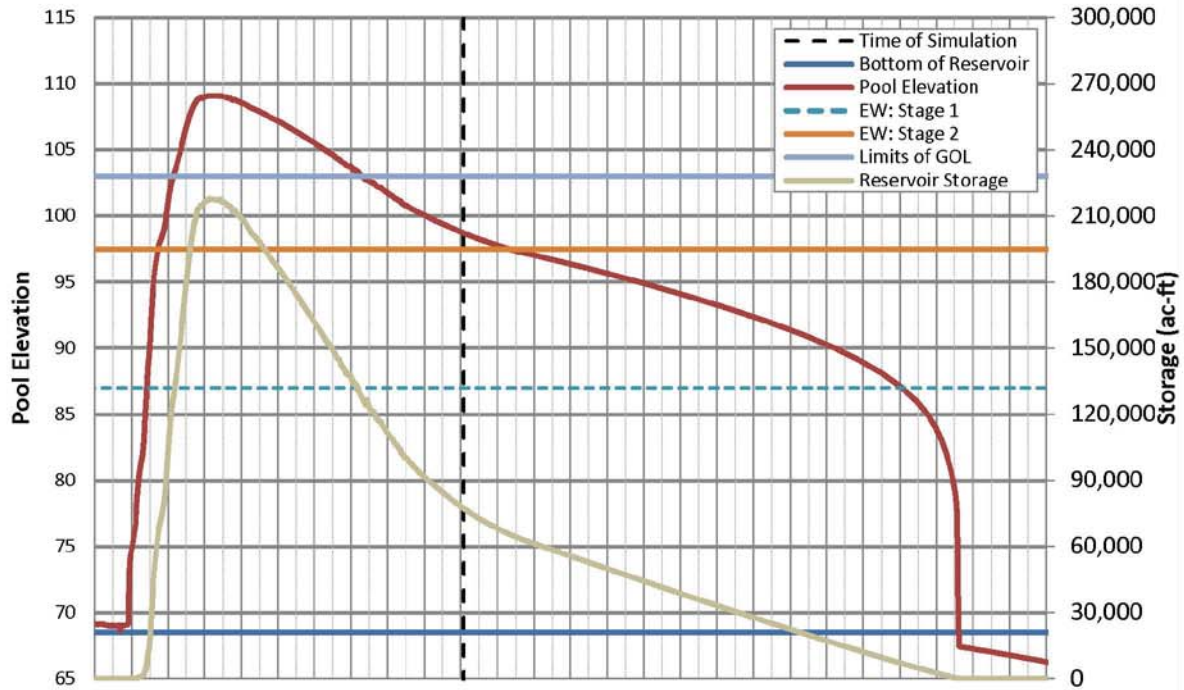
USACE005966

U.S. Army Corps of Engineers
Galveston District

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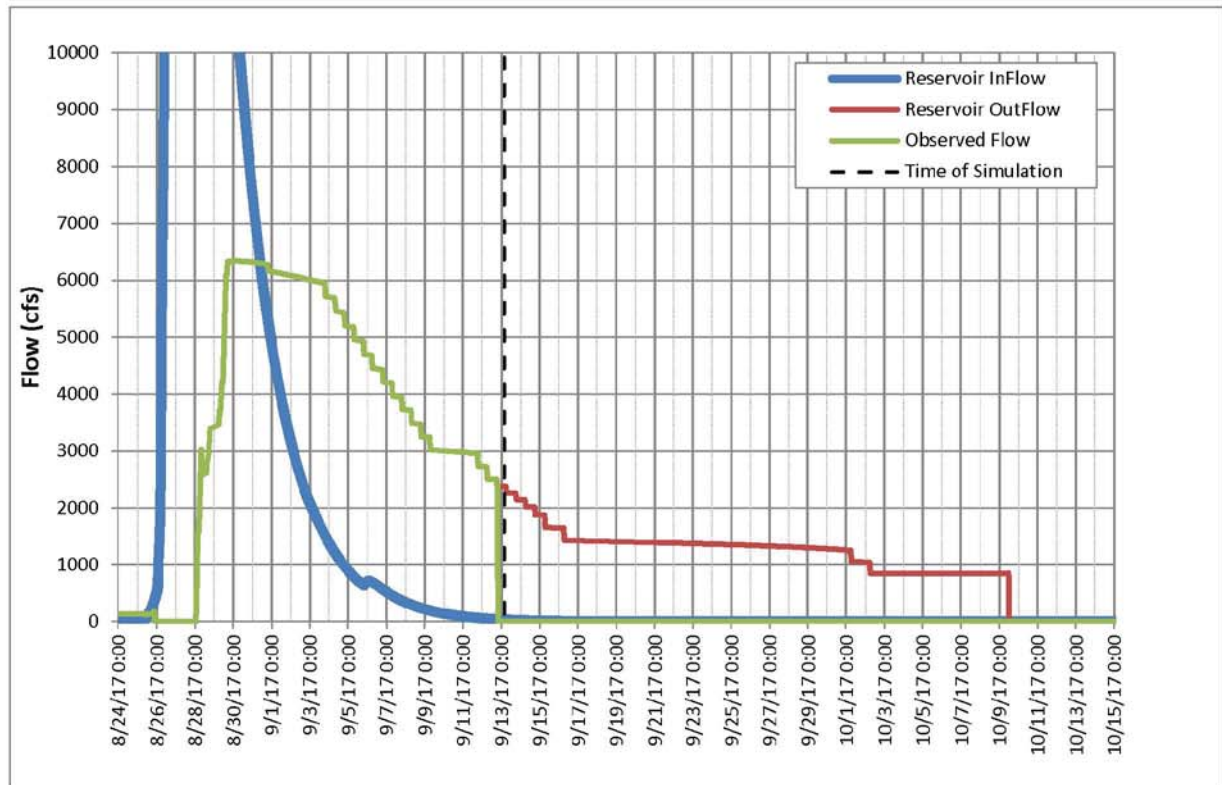
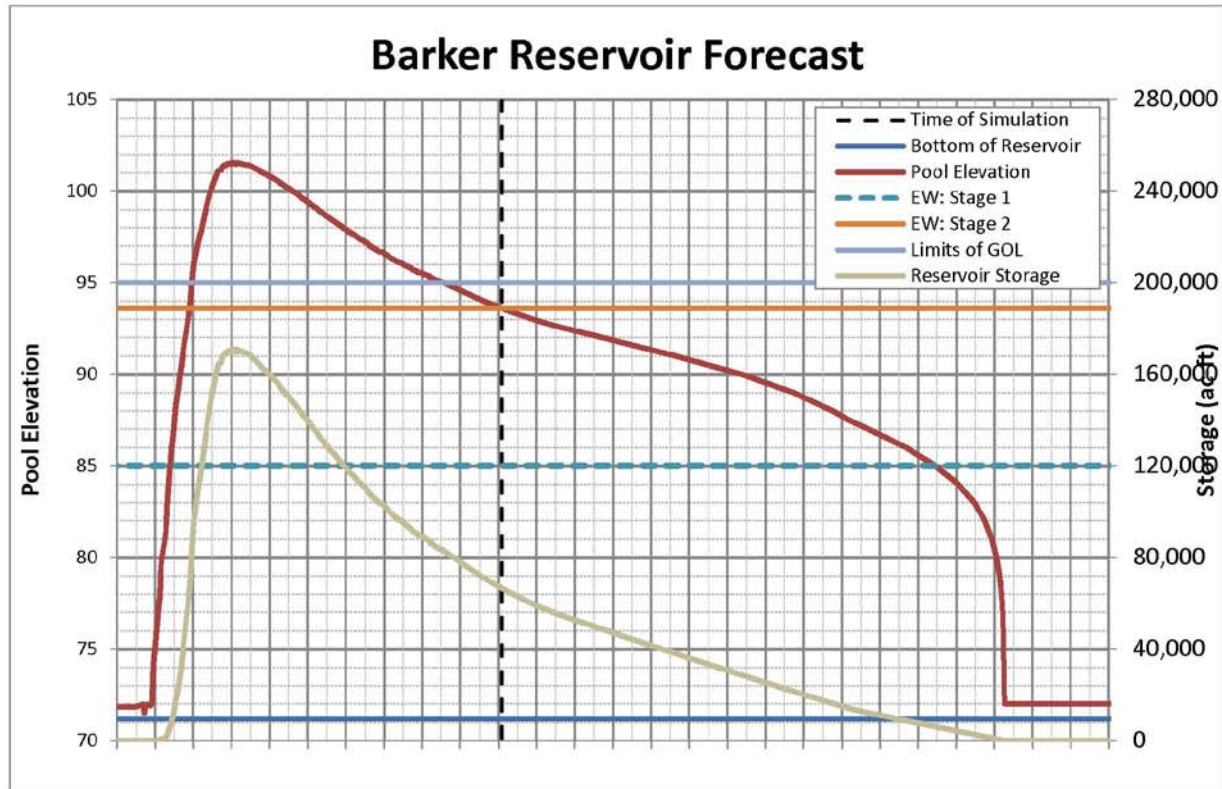


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/14/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 16 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. There is about 0.3" of rain in the forecast over the next 7-days.

At this time, Addicks is releasing approximately 2,600 cfs and Barker is releasing approximately 2,150 cfs. The pool in both reservoirs is now fully confined to government owned land. This forecast includes the prospective drawdown on discharges which will be enacted to protect both the dam faces and bayou banks. With these assumed discharge rates and no further rain, flows in Buffalo Bayou could be below 4000 cfs by tomorrow. The pools should be off Westheimer by this afternoon and off Eldridge Parkway and Hwy 6 in 4-6 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

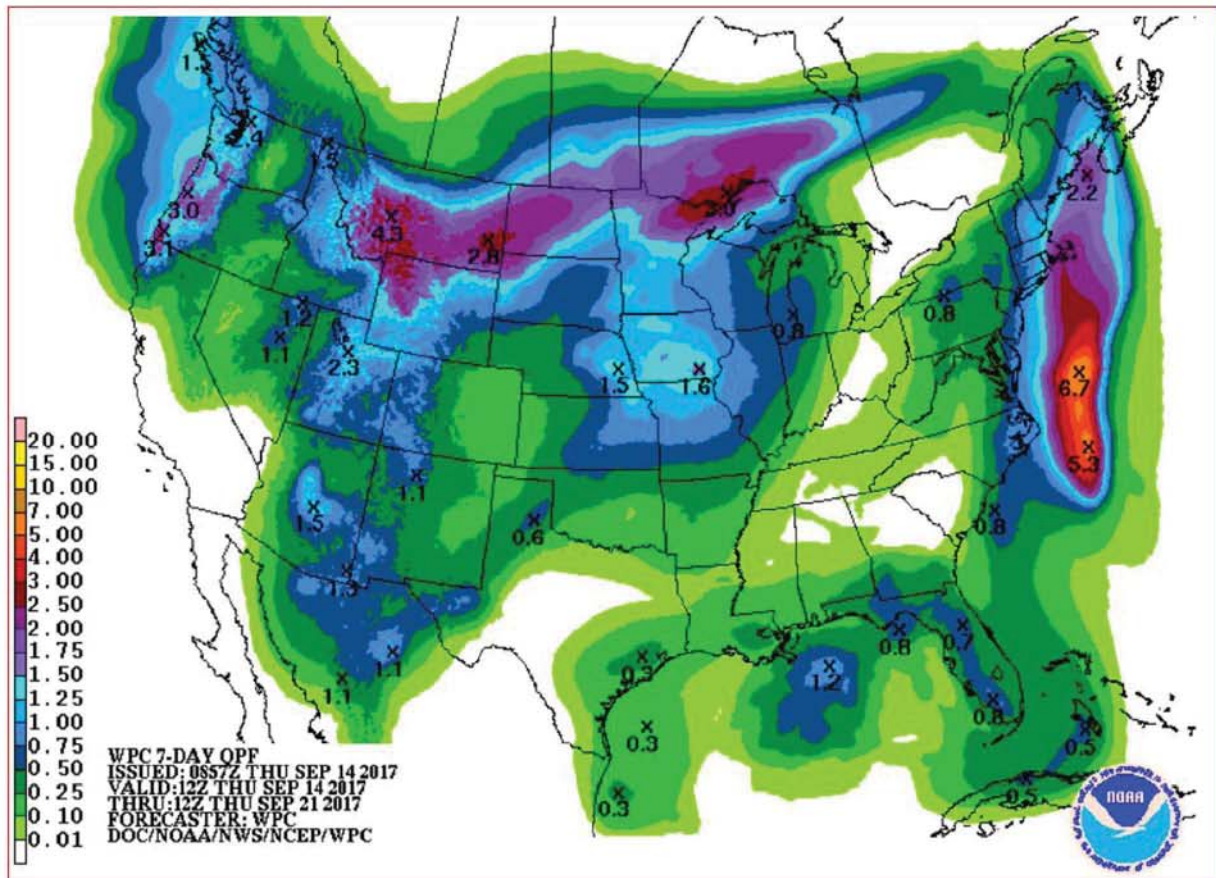
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 15 Sep 2017, 17:00 | 93.6 | 13 Sep 2017, 05:00 |
| EW, Stage 1 Res. Level | 87 | 07 Oct 2017, 24:00 | 85 | 06 Oct 2017, 07:00 |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/14/2017 04:00
- Lookback Period: 22 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 98.16 ft (NAVD88)
 - Barker: 93.34 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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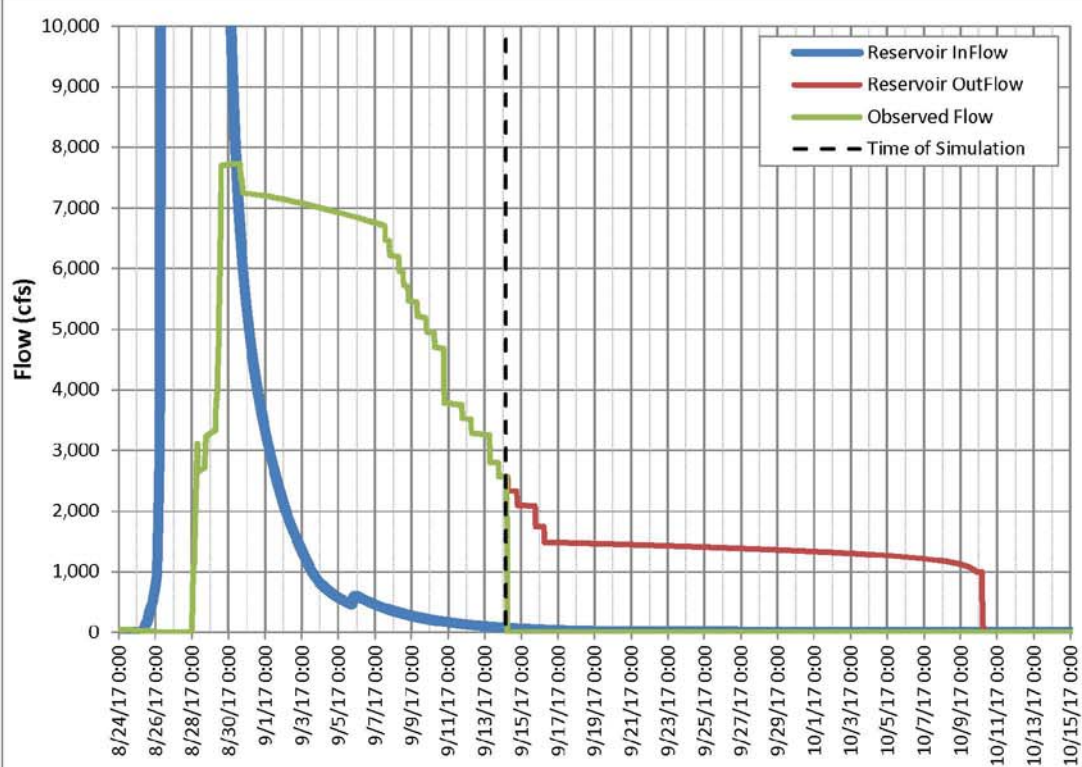
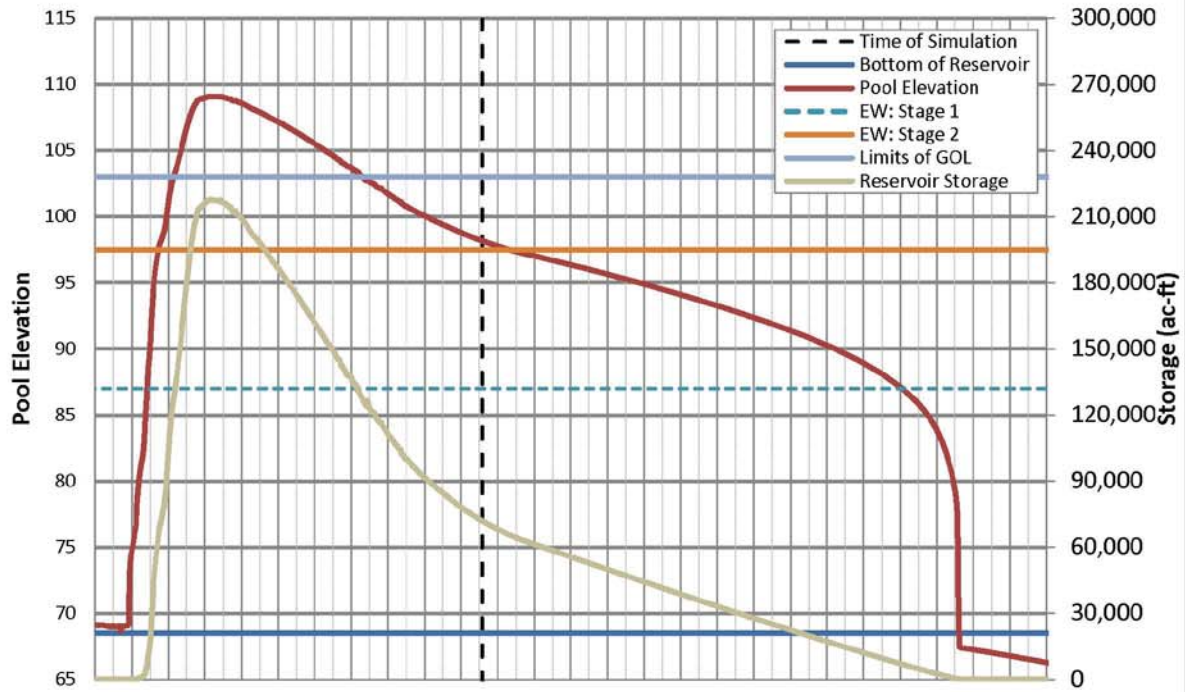
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

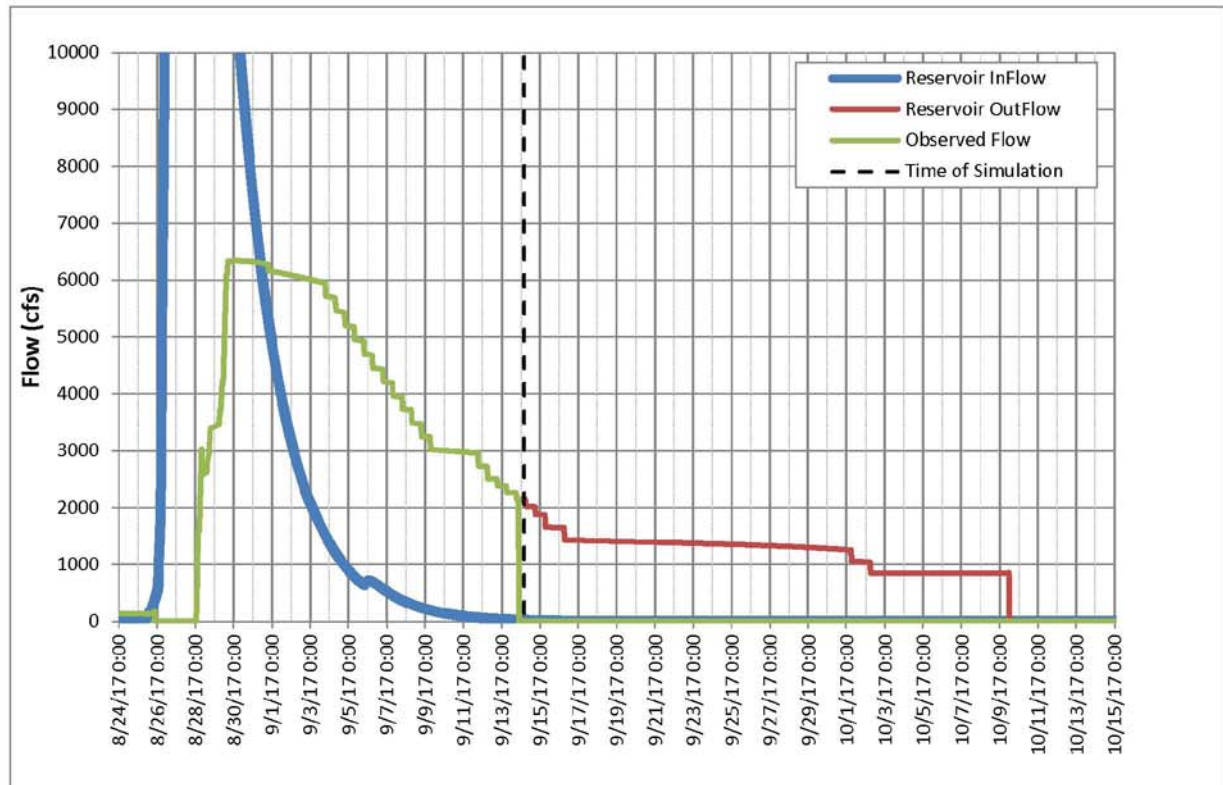
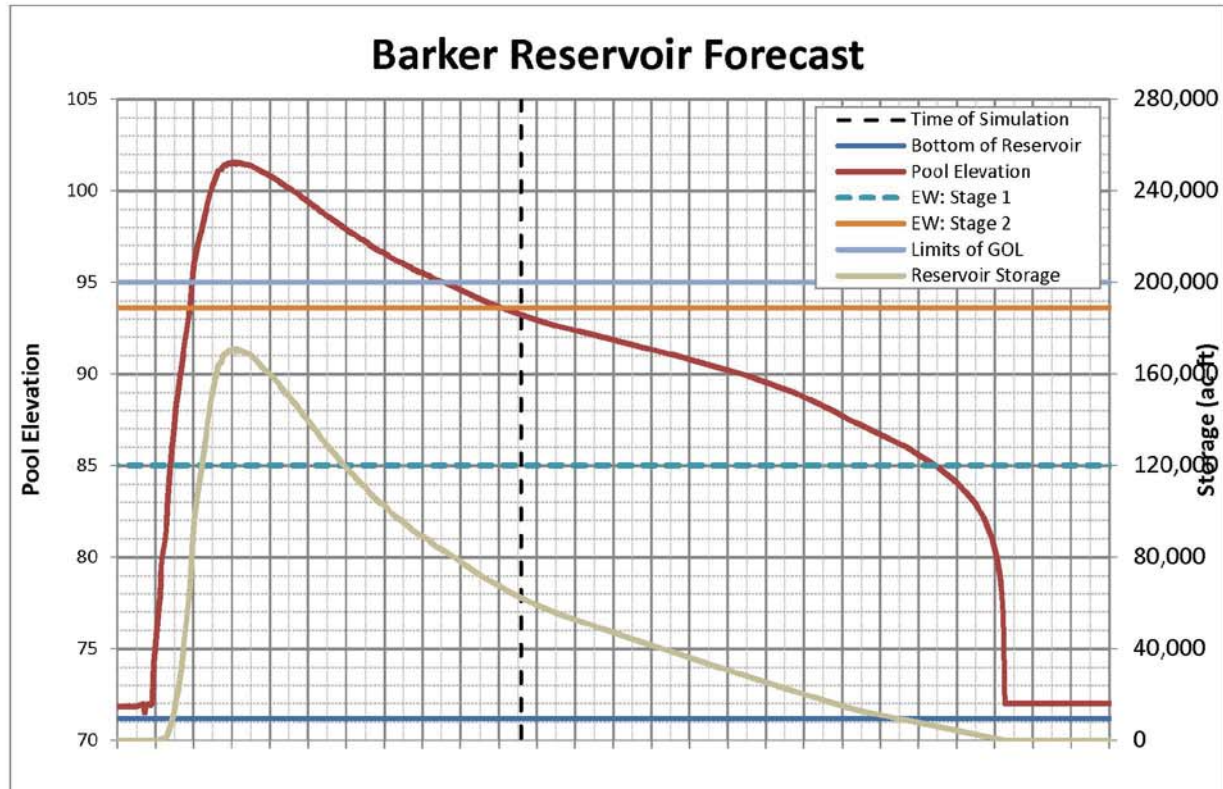
Page 3 of 4

Forecasted on:
14-Sep-17

USACE005971

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/15/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 17 days ago. The gates on both reservoirs are gradually being closed to slowly bring down the water levels in Buffalo Bayou. The Weather Service is predicting a 40% chance of rain Sunday through Wednesday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

At this time, Addicks is releasing approximately 2100 cfs and Barker is releasing approximately 1880 cfs. The drawdown schedule has more gate changes planned for today and tomorrow, at which time combined reservoir discharges will be below 3000 cfs. With these assumed discharge rates and no significant rain, the pools should be off Westheimer Parkway and off Eldridge Parkway and Highway 6 in 4 – 7 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

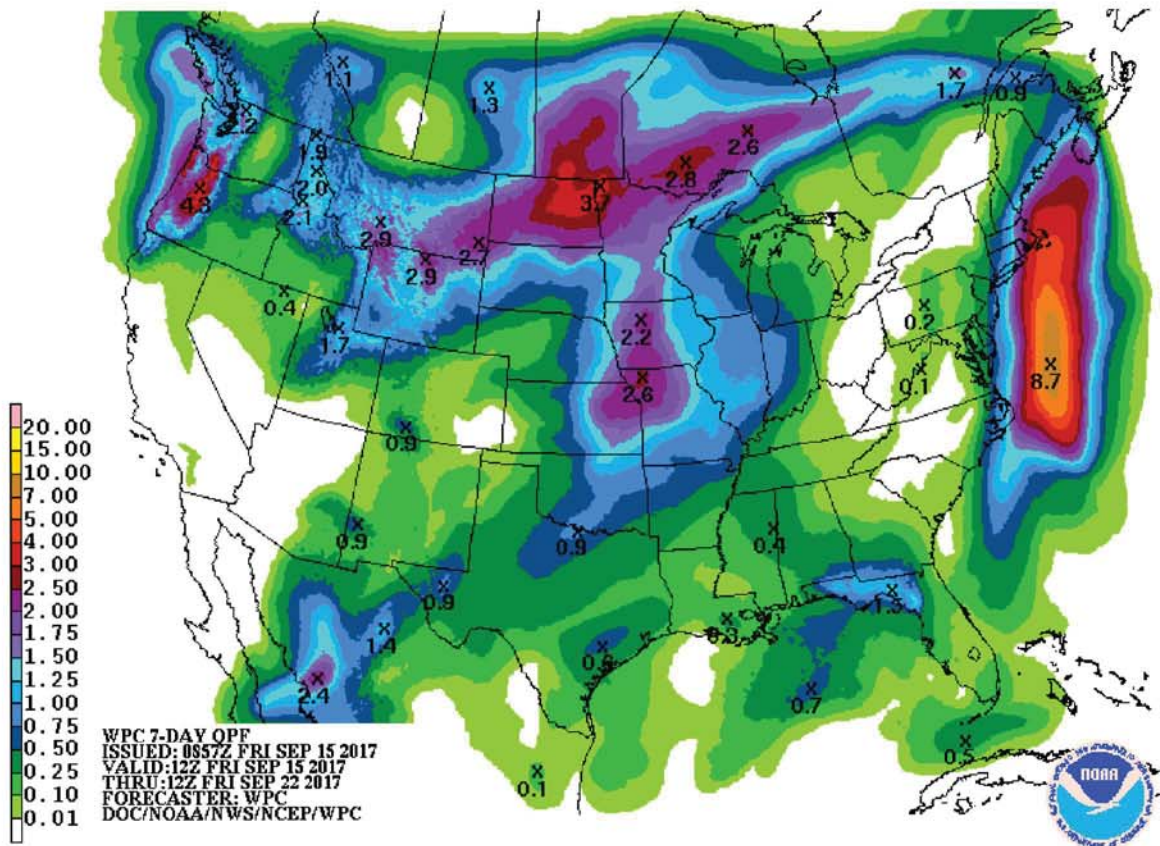
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 16 Sep 2017, 16:00 | 93.6 | 13 Sep 2017, 06:00 |
| EW, Stage 1 Res. Level | 87 | 10 October | 85 | 6 October |
| Empty | 67.5 | 4 - 6 weeks | 70.2 | 4 - 6 weeks |

Forecast Information:

- Forecast Start Time: 9/15/2017 06:00
- Lookback Period: 22 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 98.00 ft (NAVD88)
 - Barker: 92.99 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
15-Sep-17

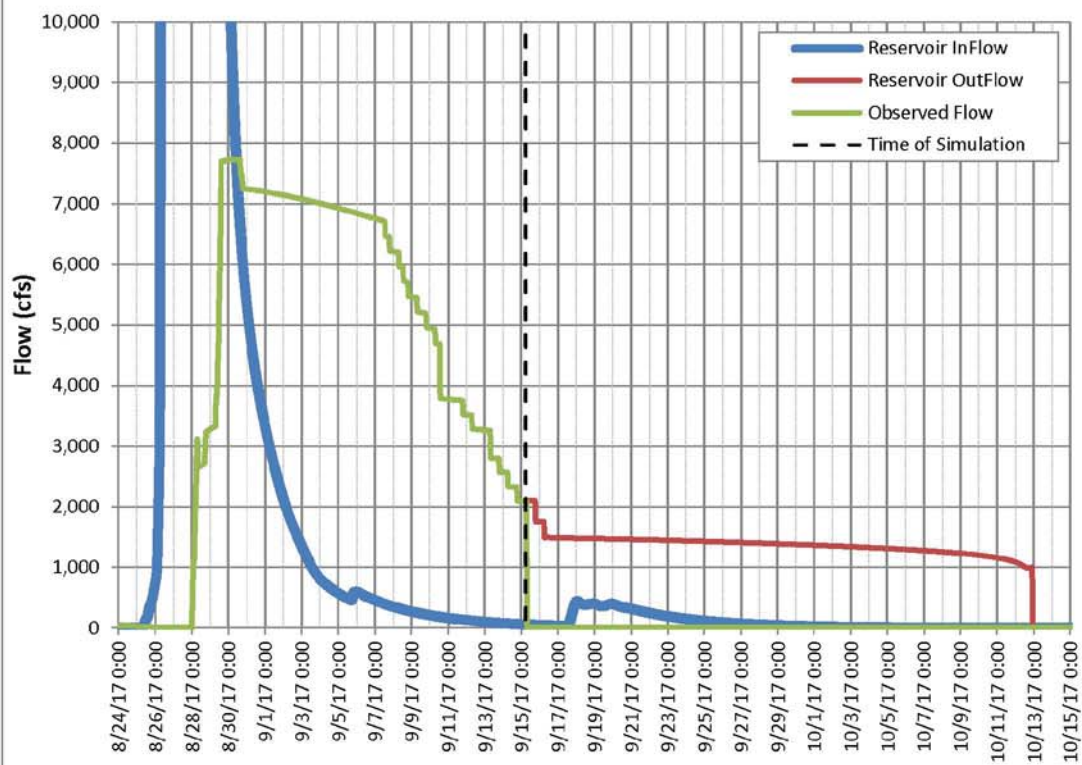
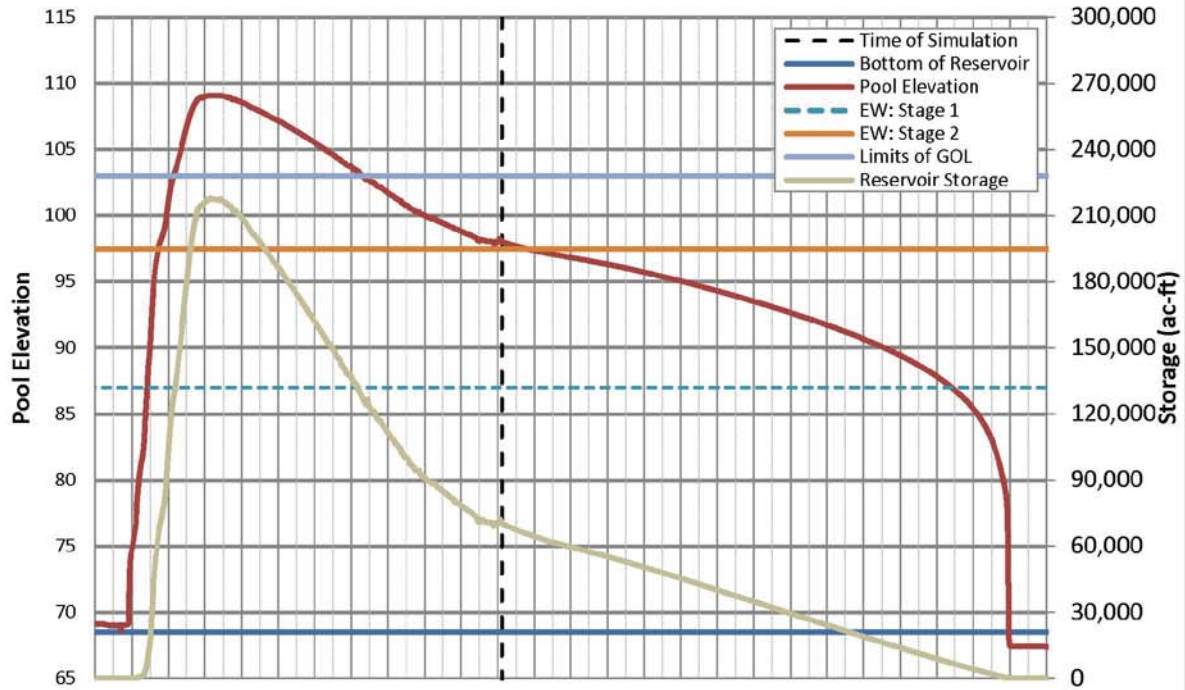
USACE005974

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

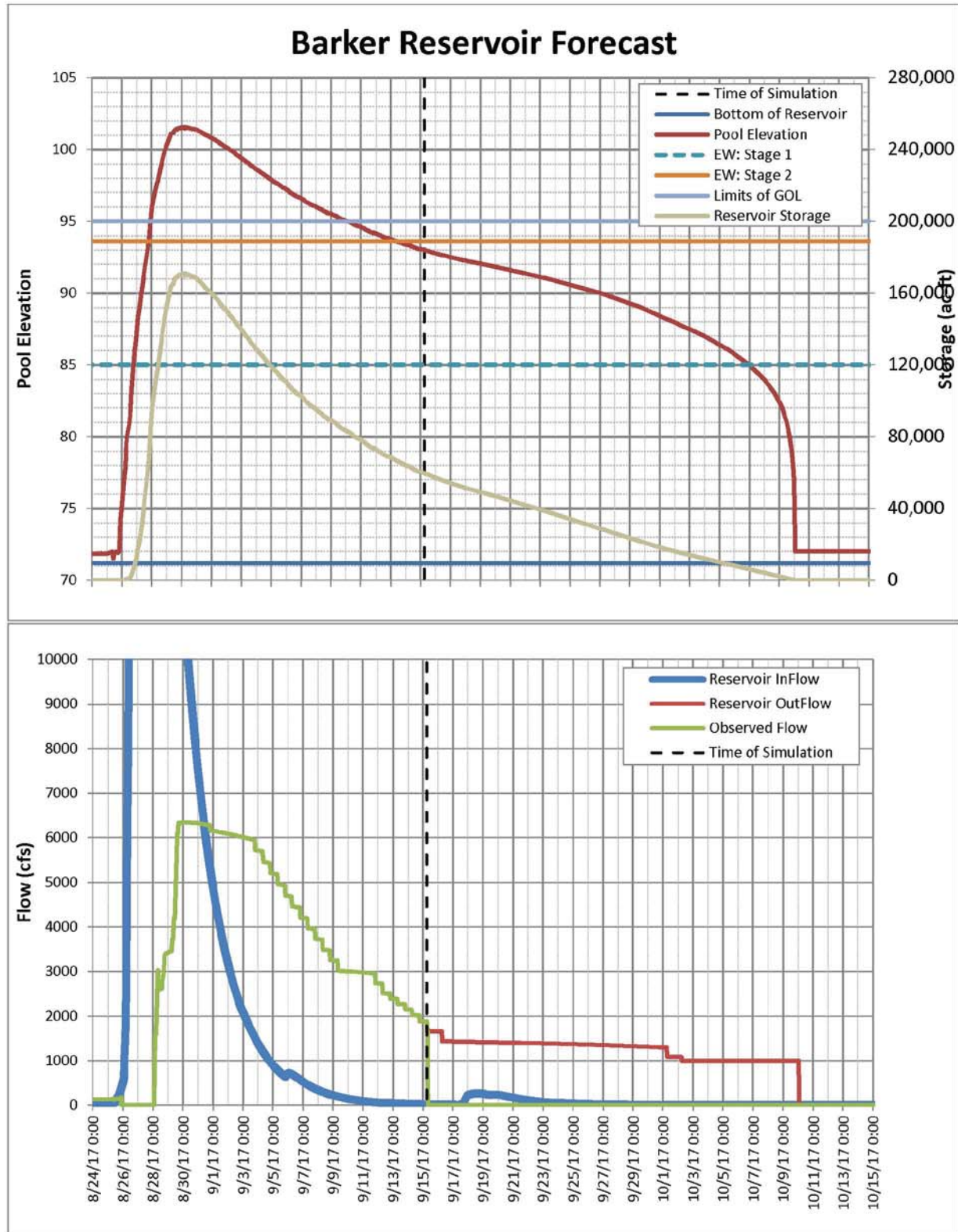
Page 3 of 4

Forecasted on:
15-Sep-17

USACE005975

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/16/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 18 days ago. The Weather Service is predicting a 20-40% chance of rain Sunday through Friday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

Gate closures began on 3 September and as of 0700 this morning, total discharge from the two reservoirs is less than 3,000 cfs. At this time, Addicks is releasing approximately 1480 cfs and Barker is releasing approximately 1440 cfs. With these assumed discharge rates and no significant rain, the pools should be off Eldridge Parkway (elevation 96.6) and Highway 6 (elevation 96.0) in 2 – 4 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

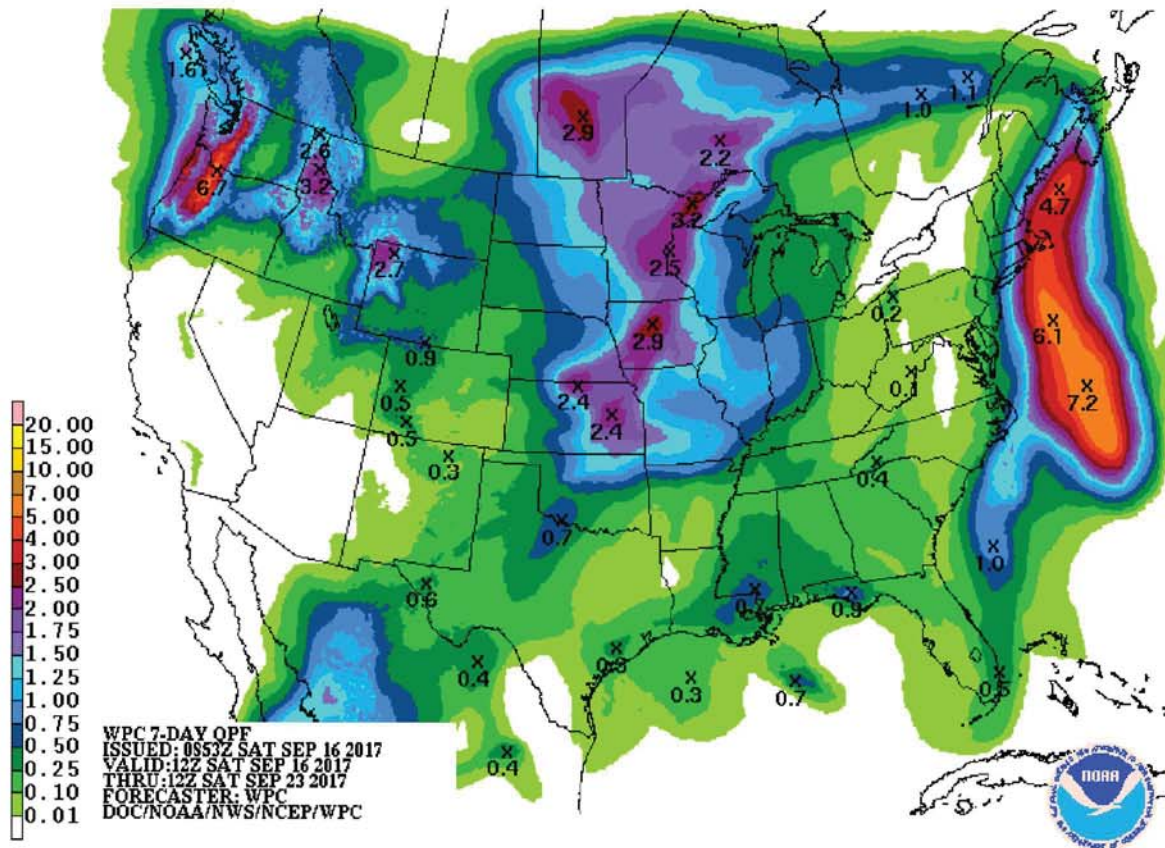
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 16 Sep 2017, 01:15 | 93.6 | 13 Sep 2017, 06:00 |
| EW, Stage 1 Res. Level | 87 | -3 weeks | 85 | -3 weeks |
| Empty | 67.5 | 4 - 5 weeks | 70.2 | 4 – 5 weeks |

Forecast Information:

- Forecast Start Time: 9/16/2017 06:00
- Lookback Period: 23 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 97.43 ft (NAVD88)
 - Barker: 92.68 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
16-Sep-17

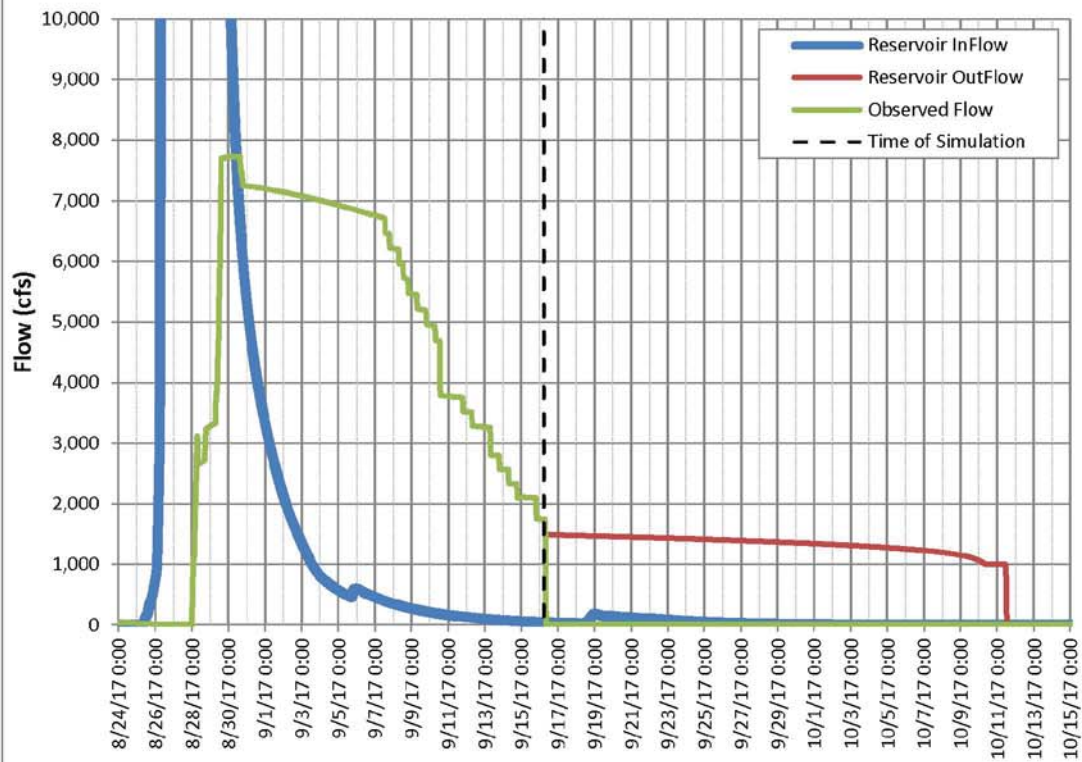
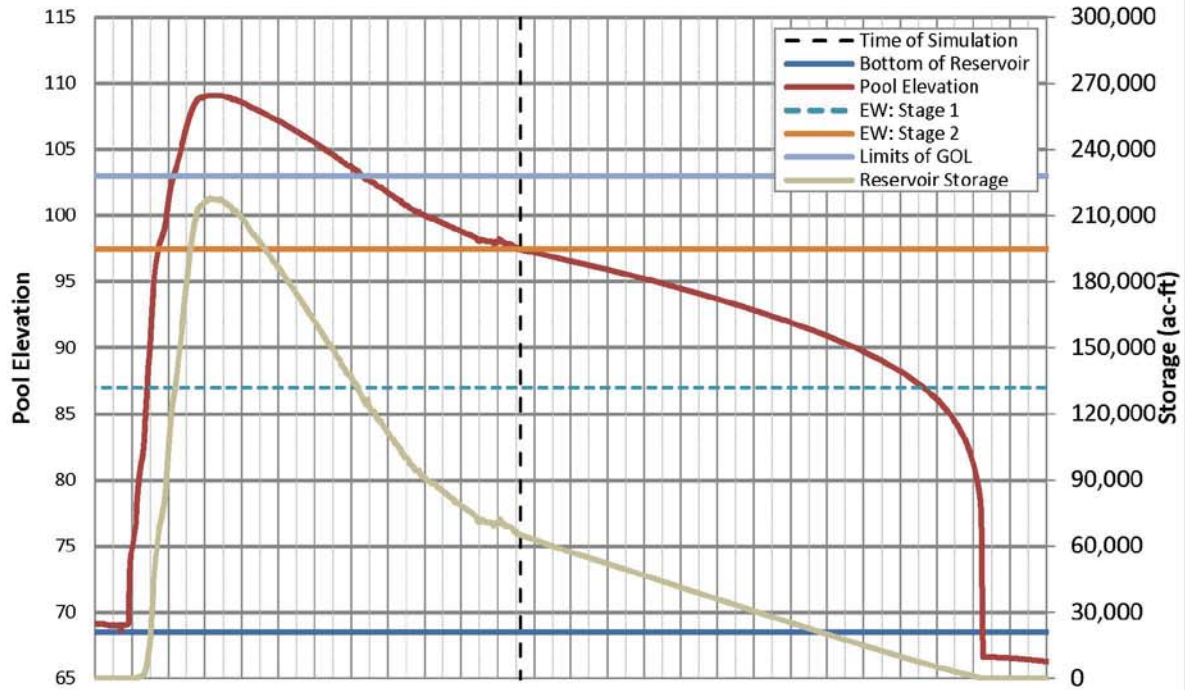
USACE005978

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

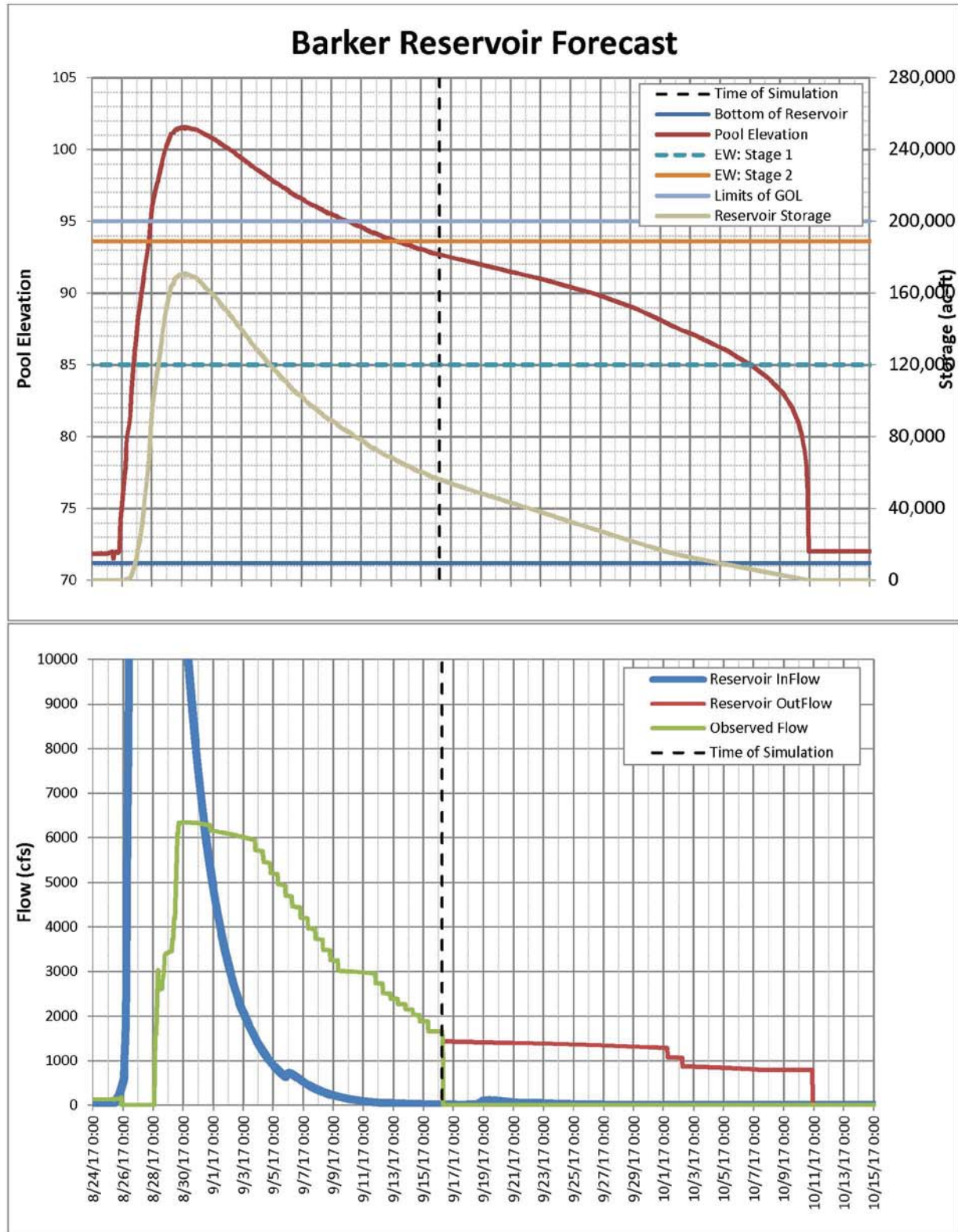
Page 3 of 4

Forecasted on:
16-Sep-17

USACE005979

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/17/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. Large releases from both reservoirs began 19 days ago. The Weather Service is predicting a 20-40% chance of rain today through Saturday, but the QPF is show accumulations of about half an inch of rain over the next 7-days.

Gate closures began on 3 September and as of yesterday, total discharge from the two reservoirs is less than 3,000 cfs. At this time, Addicks is releasing approximately 1480 cfs and Barker is releasing approximately 1430 cfs. With these assumed discharge rates and no significant rain, the pools should be off Eldridge Parkway (elevation 96.6) and Highway 6 (elevation 96.0) in 2 – 4 days.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

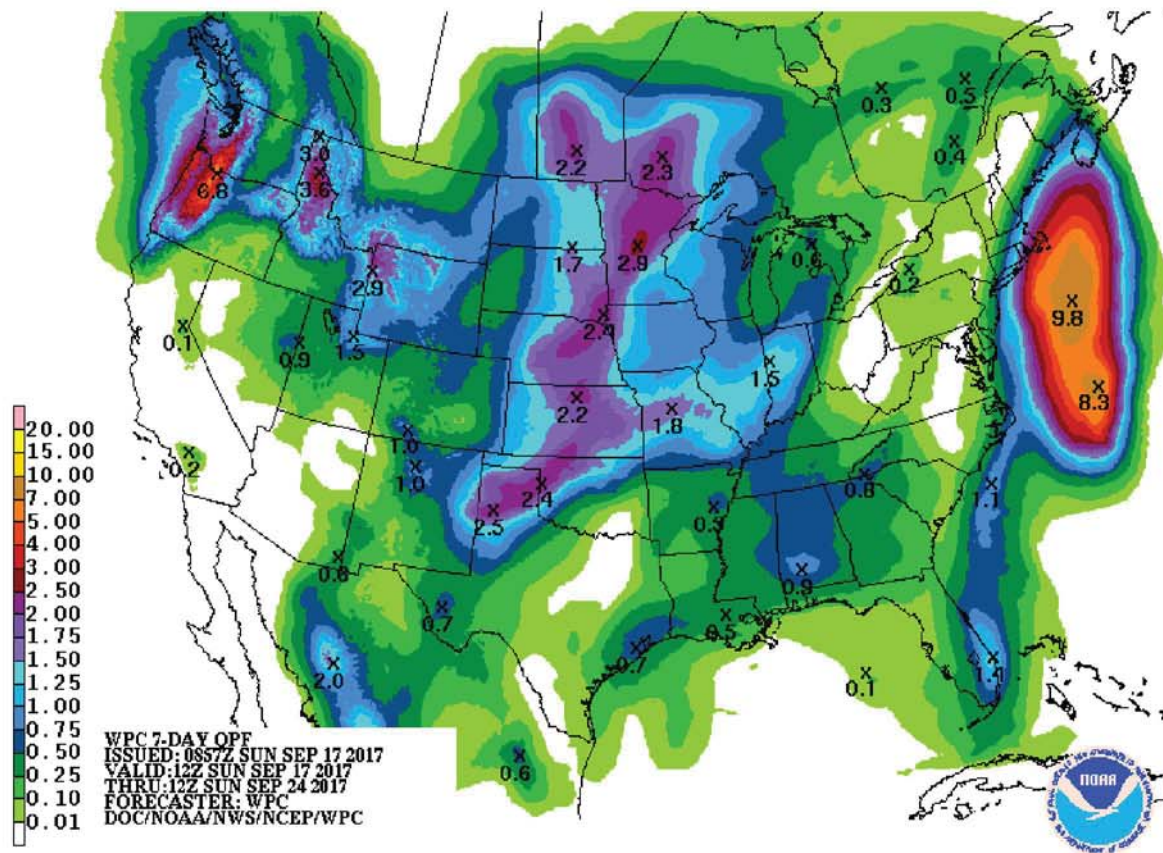
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 16 Sep 2017, 01:15 | 93.6 | 13 Sep 2017, 06:00 |
| EW, Stage 1 Res. Level | 87 | -3 weeks | 85 | -3 weeks |
| Empty | 67.5 | 4 - 5 weeks | 70.2 | 4 – 5 weeks |

Forecast Information:

- Forecast Start Time: 9/17/2017 06:00
- Lookback Period: 24 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir levels
 - Addicks: 97.19 ft (NAVD88)
 - Barker: 92.43 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
17-Sep-17

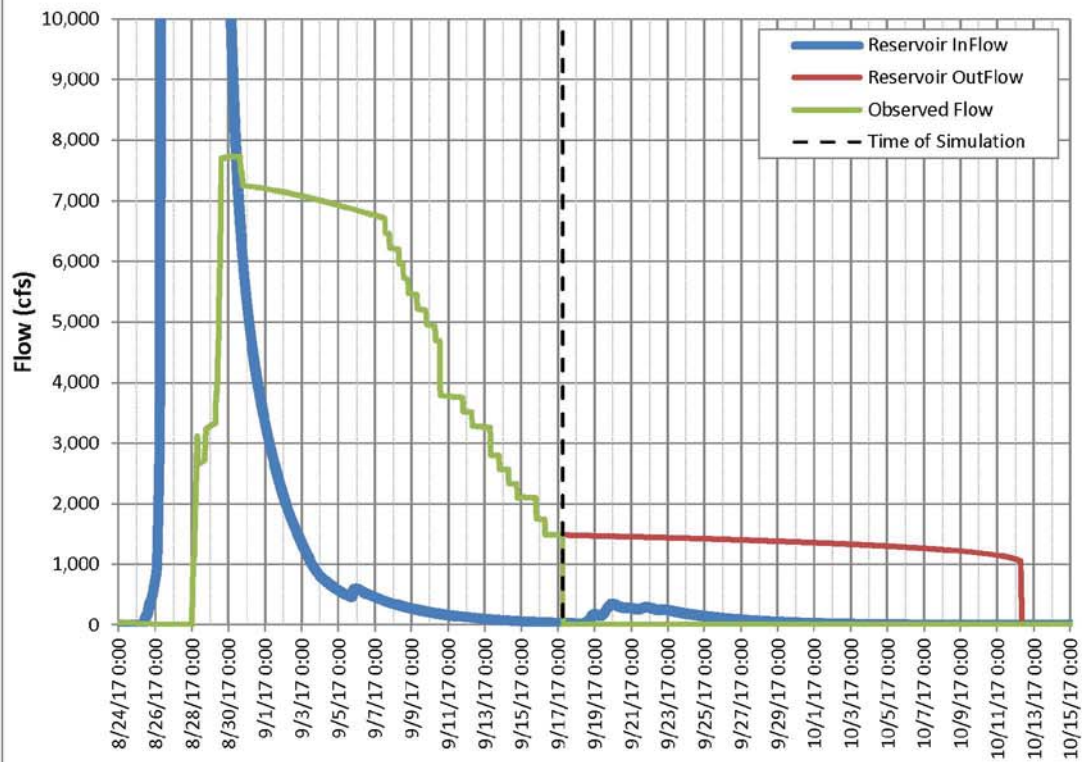
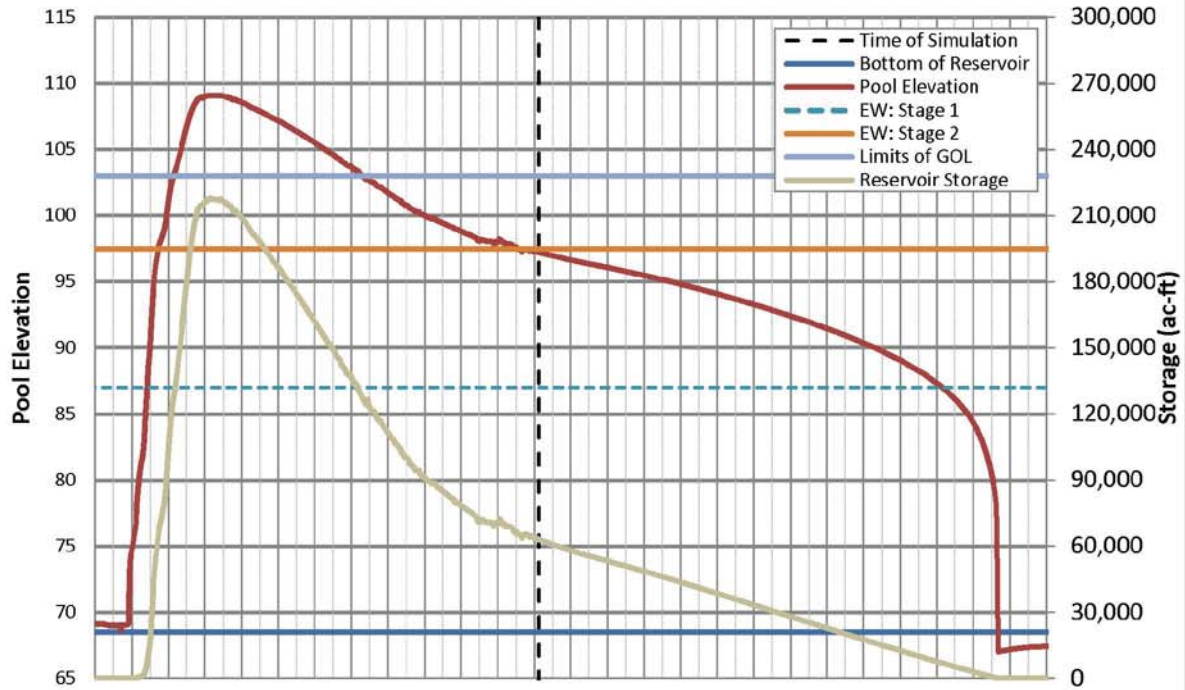
USACE005982

U.S. Army Corps of Engineers
Galveston District

DRAFT

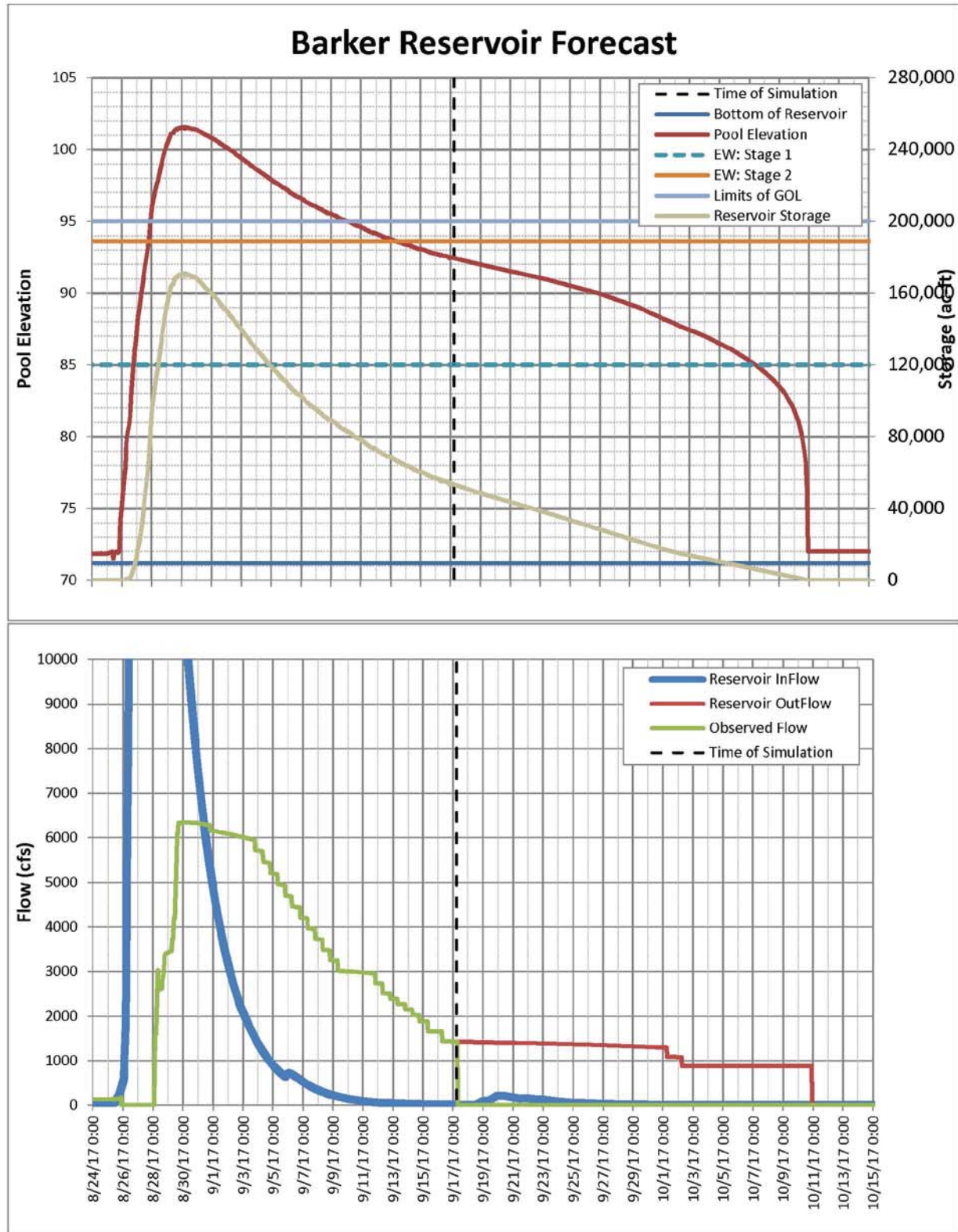


Addicks Reservoir Forecast



U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/18/2017

The Addicks and Barker watersheds averaged about 34 inches across the watersheds due to Hurricane Harvey. The reservoirs have not seen any rain in the last week. The Weather Service is predicting a 20-50% chance of rain today through Sunday, but the QPF is show accumulations of less than an inch of rain over the next 7-days.

At this time, Addicks is releasing approximately 1470 cfs and Barker is releasing approximately 1420 cfs. With these assumed discharge rates and no significant rain, the pools should be off Eldridge Parkway (elevation 96.6) tomorrow and Highway 6 (elevation 96.0) by Thursday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

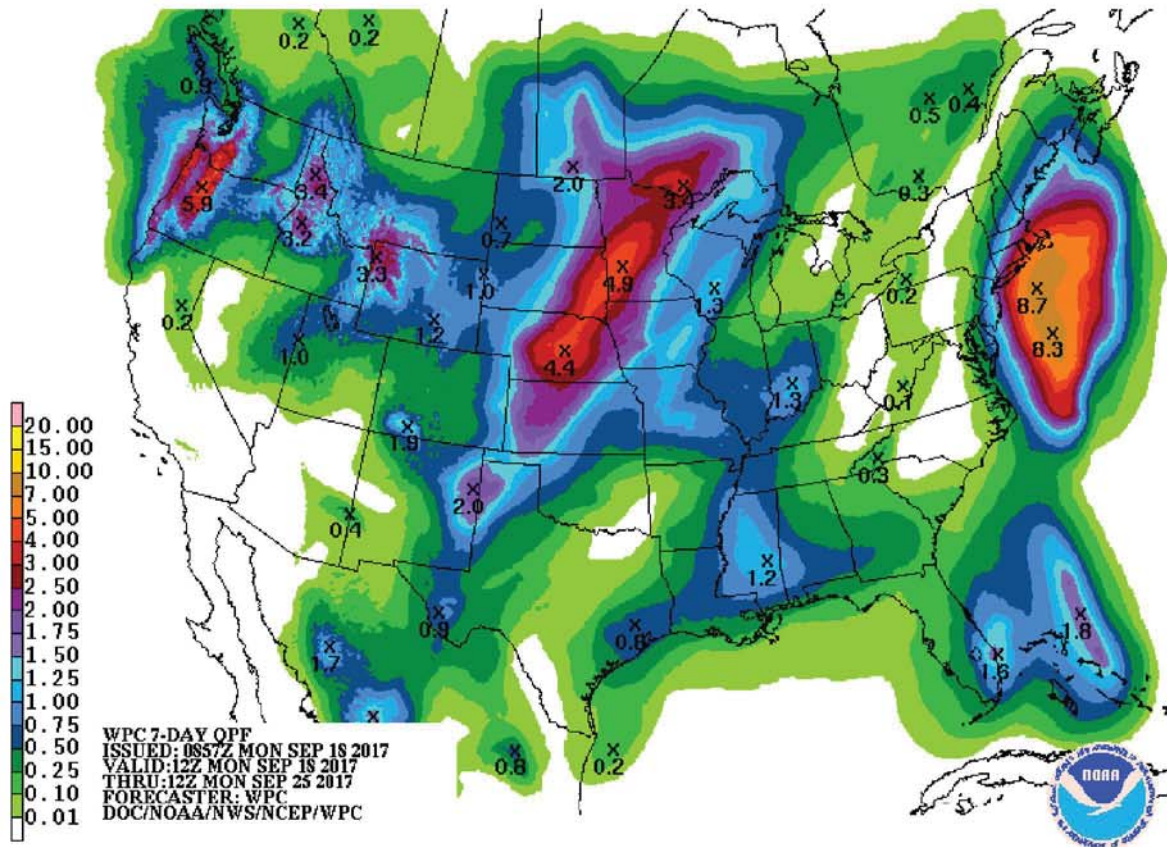
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| last home flooded | 103.4 | 7 Sep 2017, 06:00 | 97.1 | 6 Sep 2017, 4:30 |
| Government Owned Land | 103 | 7 Sep 2017, 14:45 | 95 | 10 Sep 2017, 03:00 |
| EW, Stage 2 Res. Level | 97.46 | 16 Sep 2017, 01:15 | 93.6 | 13 Sep 2017, 06:00 |
| EW, Stage 1 Res. Level | 87 | -3 weeks | 85 | -3 weeks |
| Empty | 67.5 | 4 - 5 weeks | 70.2 | 4 - 5 weeks |

Forecast Information:

- Forecast Start Time: 9/18/2017 09:00
- Lookback Period: 25 days
- Forecast End Time: 10/15/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir 96.88.19 ft (NAVD88)
 - Barker: 92.11 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

DRAFT



7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
18-Sep-17

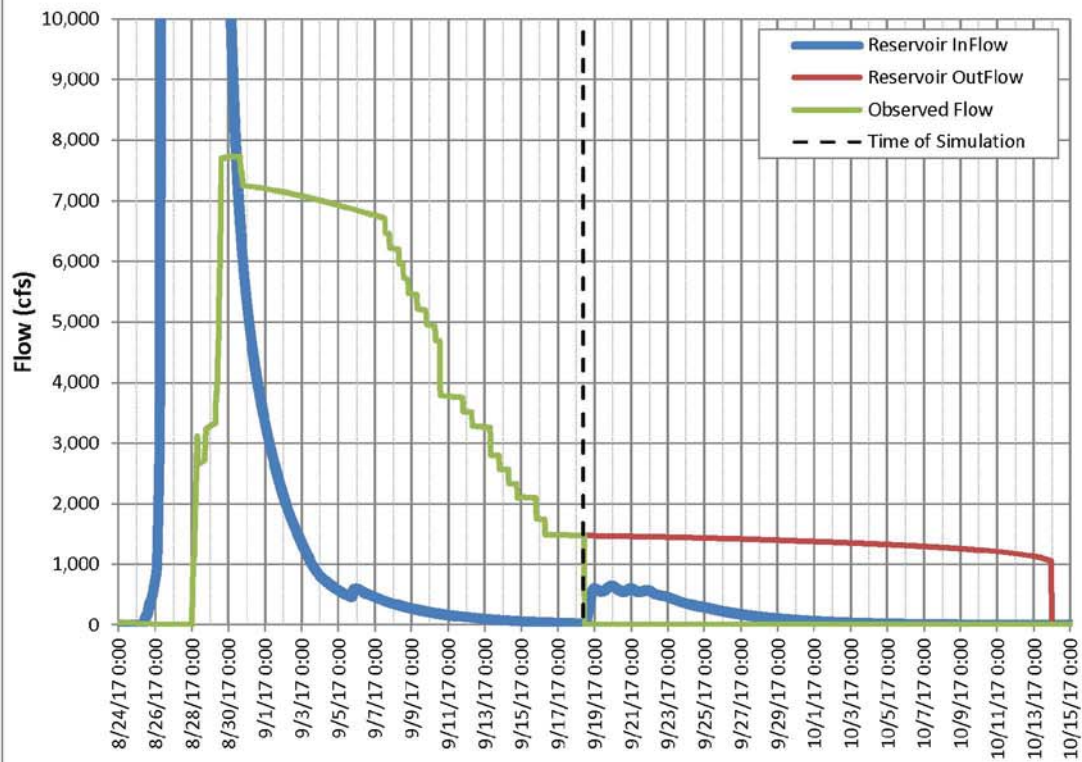
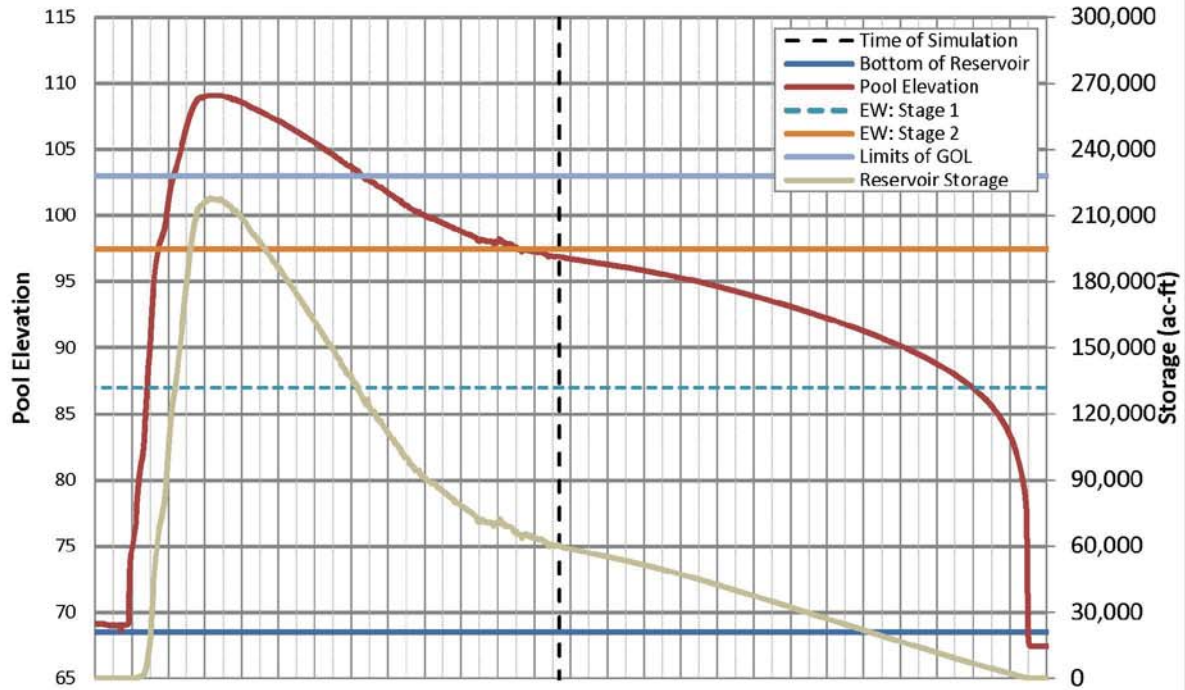
USACE005986

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

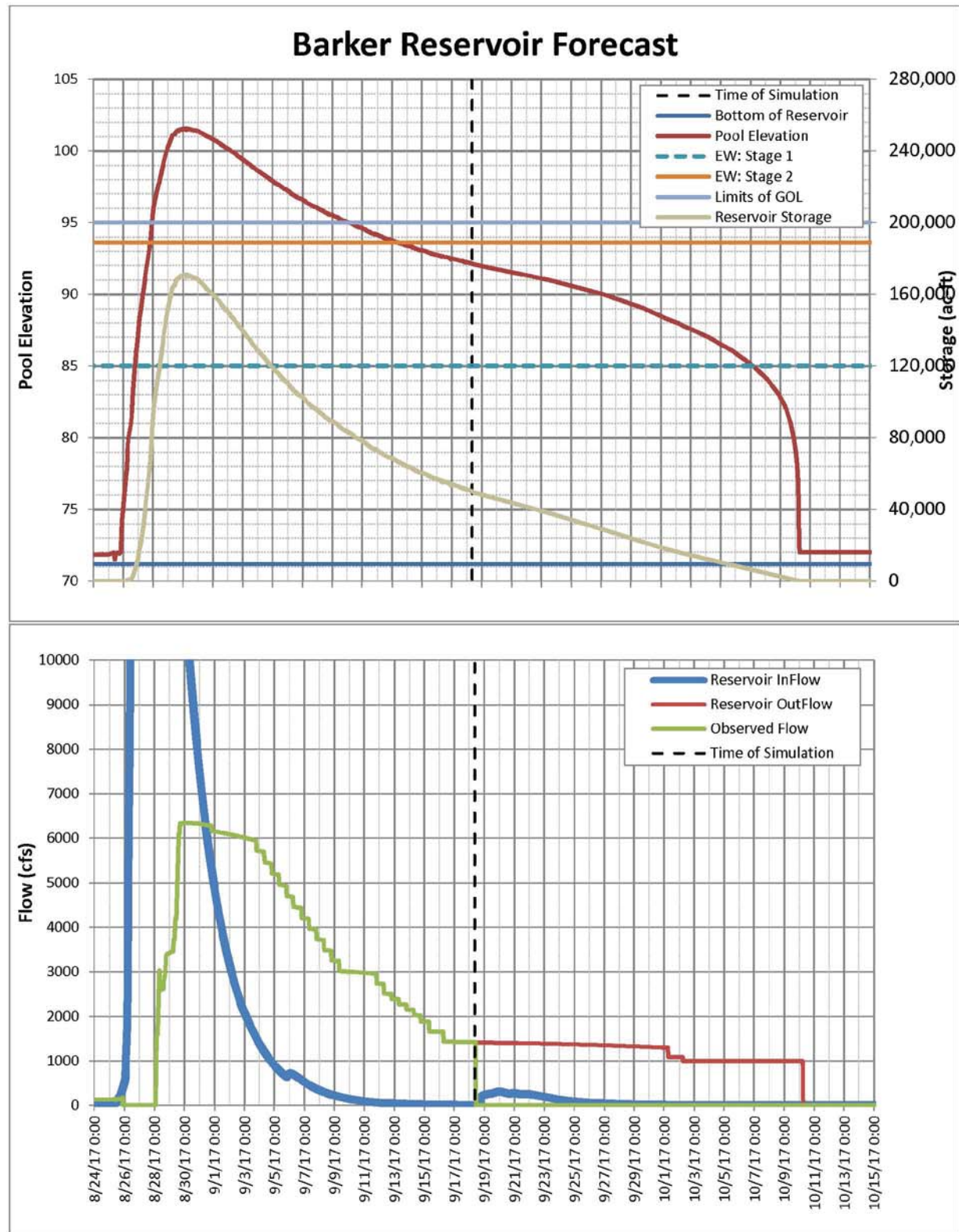
Page 3 of 4

Forecasted on:
18-Sep-17

USACE005987

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/19/2017

Last night, the Addicks and Barker watersheds received the first substantial rain since Hurricane Harvey left the area 19 days ago. Barker got about an inch of rain, while Addicks received over two inches across the watershed. Gates were closed at both reservoirs last night. The weather service is predicting a 20-40% chance of rain today through Monday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

This forecast assumes that due to the large amount of moisture in the area and the uncertainty with predicted thunderstorms that the gates will not be reopened until Thursday morning. Due to the runoff from last night, it is likely that Addicks Reservoir will exceed the Extended Watch, Stage 2 level later tonight.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

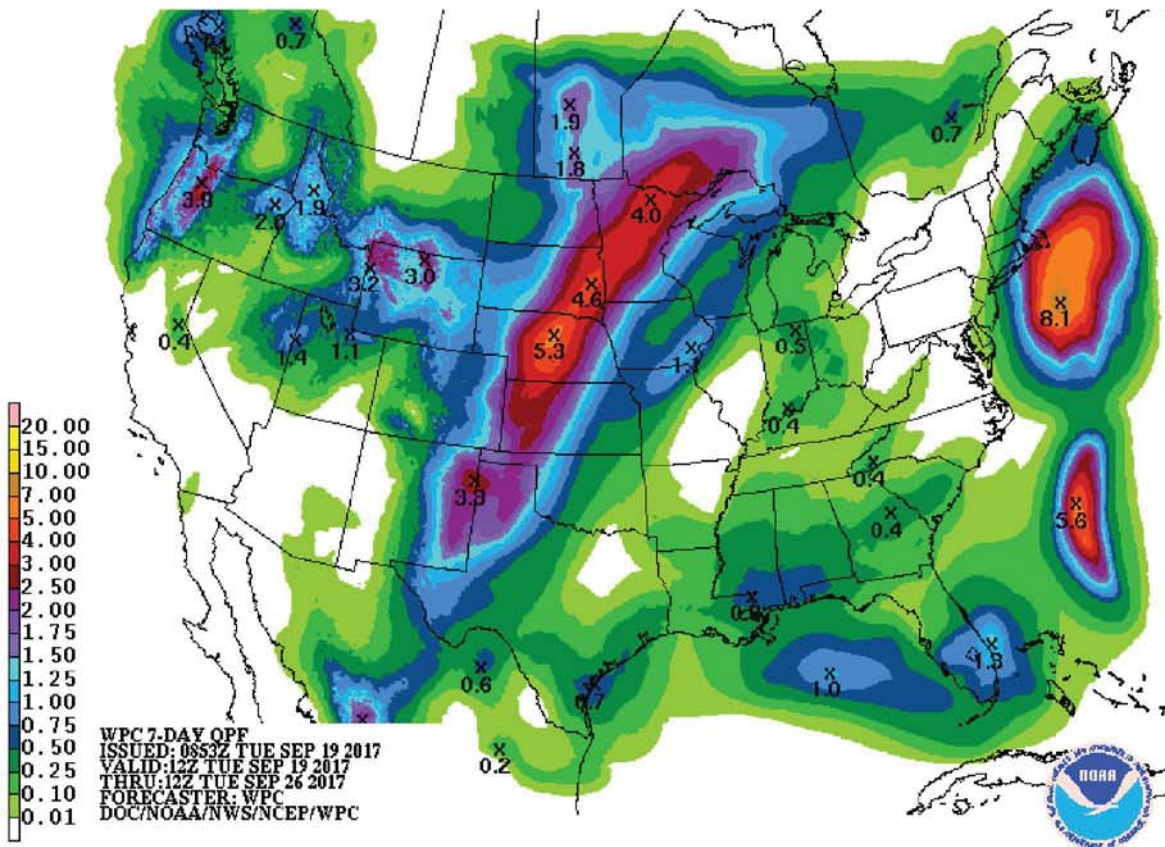
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 98.0 | 21 Sep 2017, 0800 | 92.6 | 21 Sep 2017, 0800 |
| EW, Stage 2 Res. Level | 97.46 | 19 Sep 2017, 2100 | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | -4 weeks | 85 | -4 weeks |
| Empty | 67.5 | -6 weeks | 70.2 | -6 weeks |

Forecast Information:

- Forecast Start Time: 9/19/2017 07:00
- Lookback Period: 26 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 97.29 ft (NAVD88)
 - Barker: 92.16 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
19-Sep-17

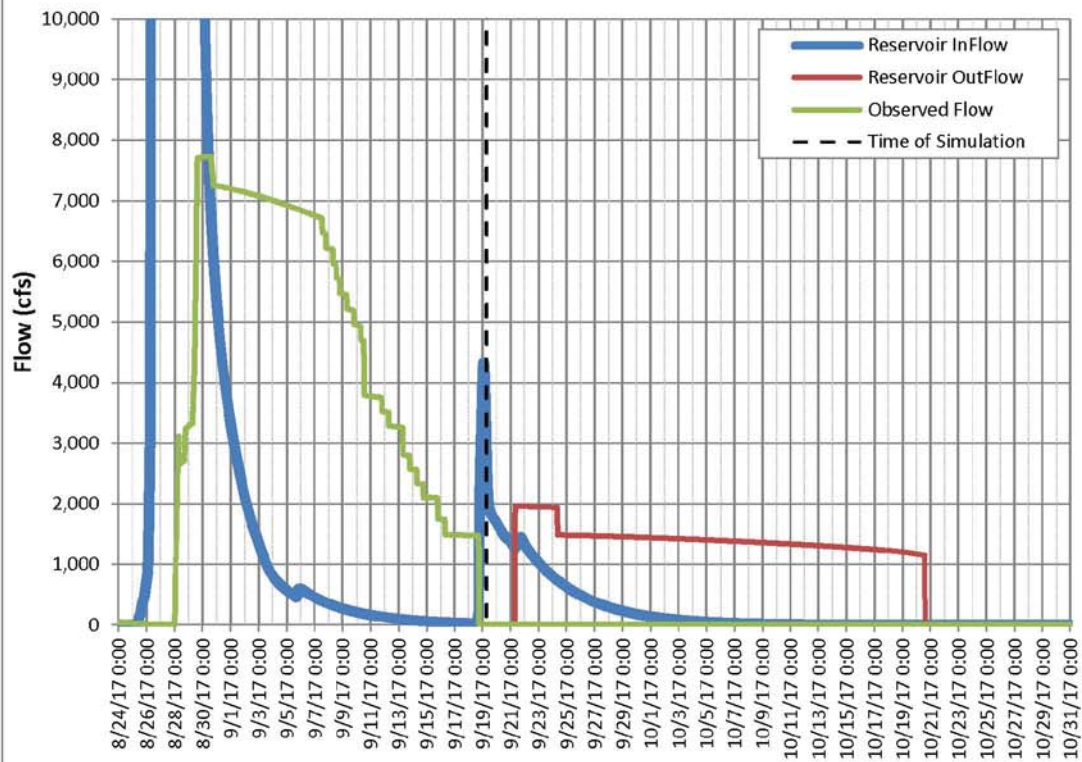
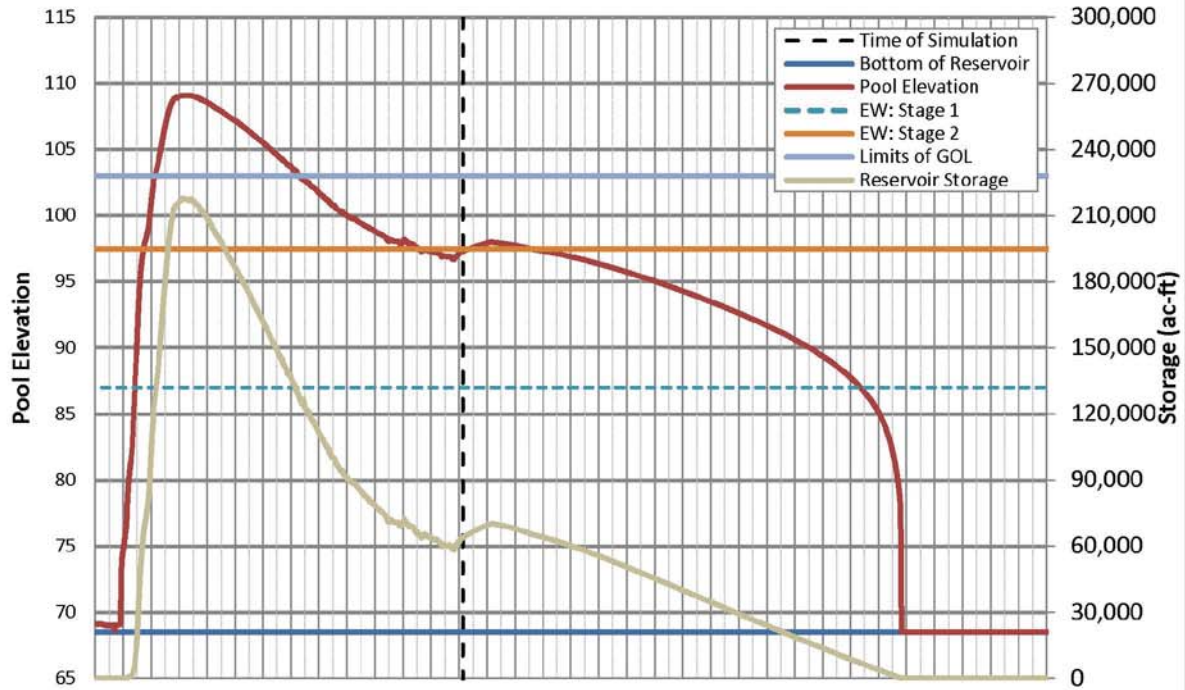
USACE005990

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

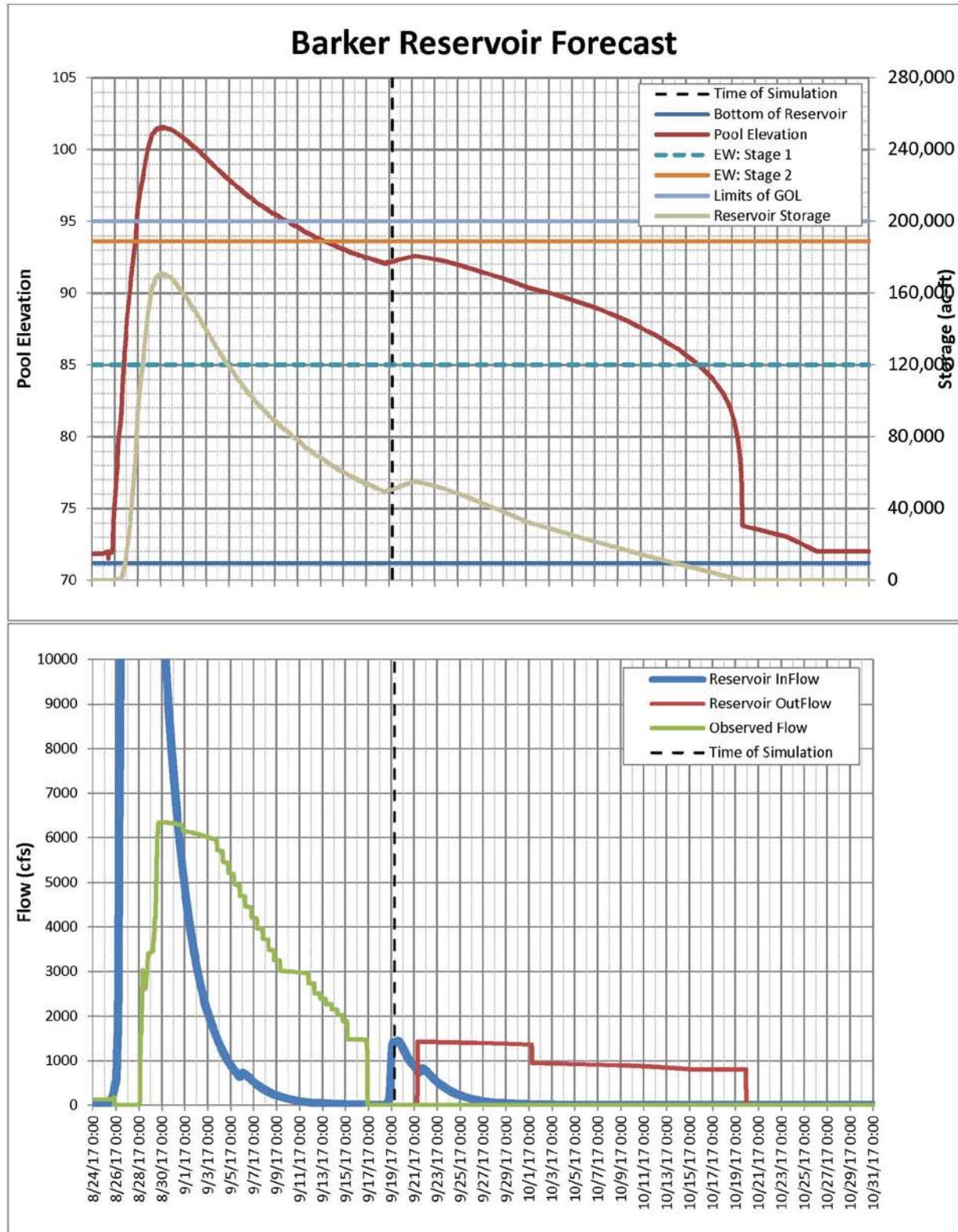
Page 3 of 4

Forecasted on:
19-Sep-17

USACE005991

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/20/2017

The Addicks and Barker watersheds only received trace amounts of rainfall in the last 24-hours. Gates were opened at both reservoirs yesterday afternoon, releasing approximately 970 cfs from Addicks and 490 cfs from Barker. Releases are expected to increase later today to 1400 cfs from Addicks and 700 cfs from Barker. The weather service is predicting a 20-40% chance of rain today through Monday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

This forecast assumes that another gate change will be made on Friday and then again on Monday. With the currently forecasted discharges and no significant rain, the pool will be below Highway 6 (elevation 96.0) in about a week.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

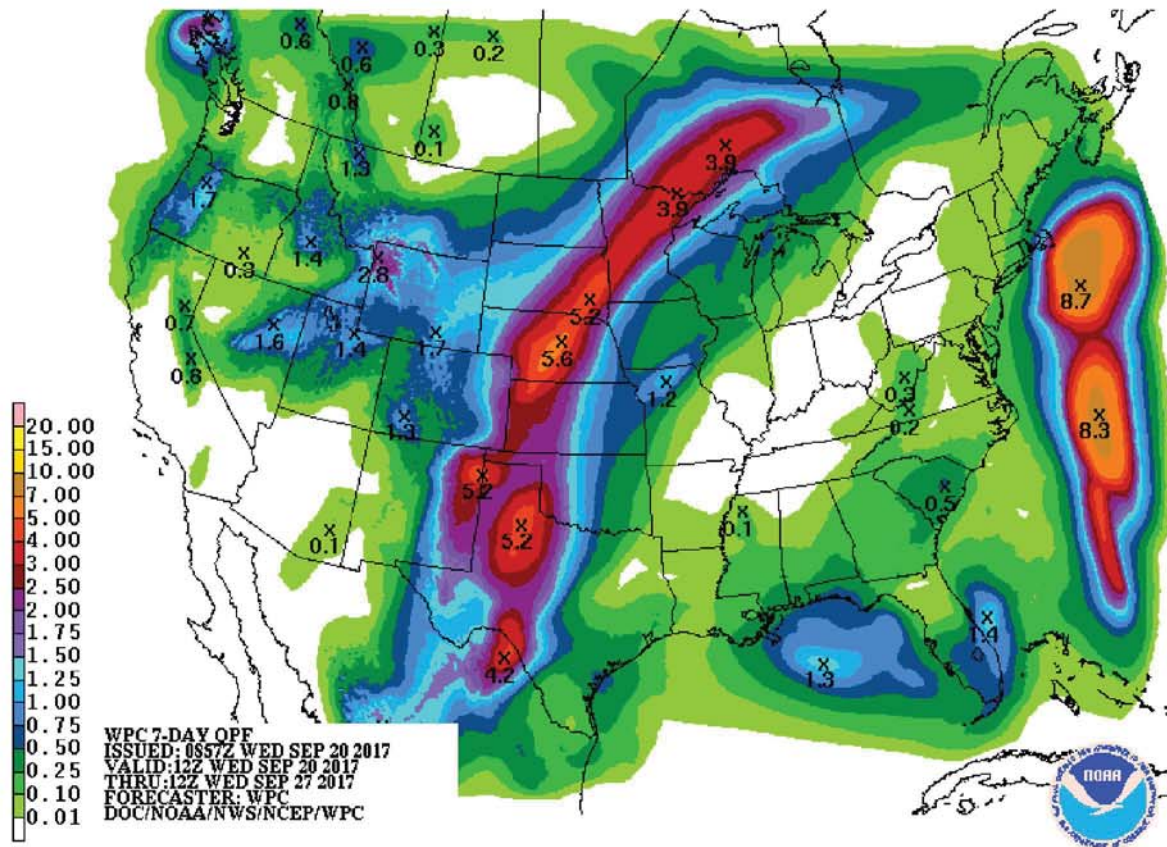
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | 3-4 weeks | 85 | 3-4 weeks |
| Empty | 67.5 | -4 weeks | 70.2 | -4 weeks |

Forecast Information:

- Forecast Start Time: 9/20/2017 09:00
- Lookback Period: 27 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 97.26 ft (NAVD88)
 - Barker: 92.07 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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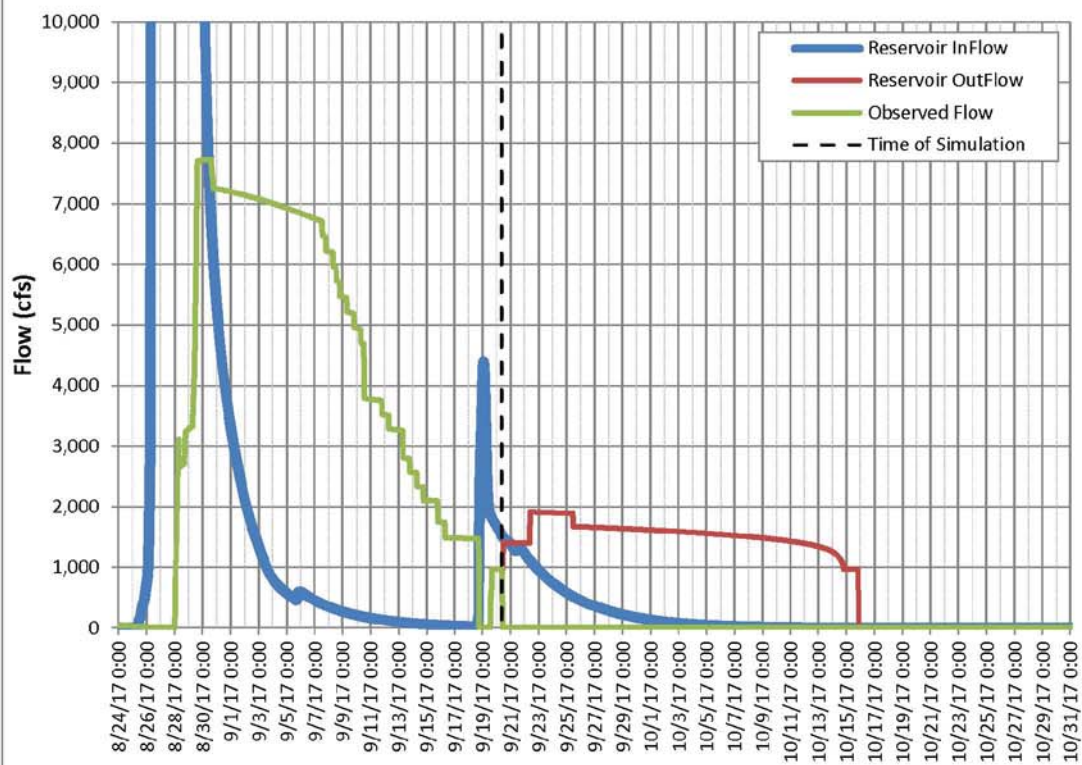
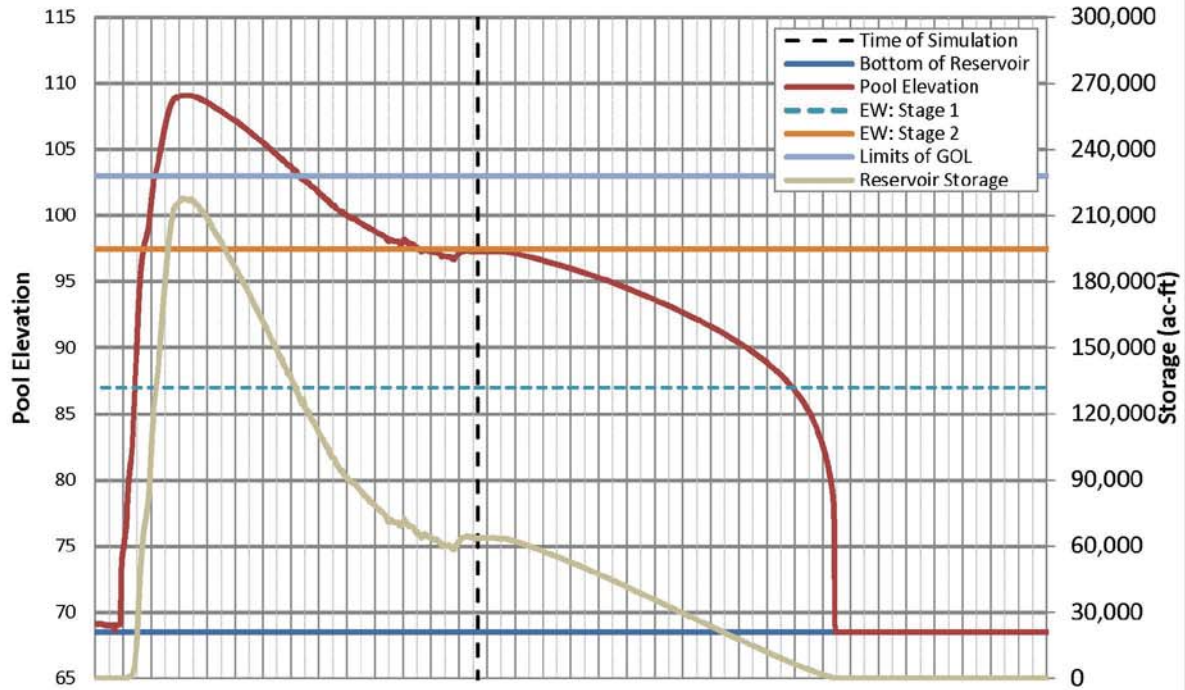
7-day QPF

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

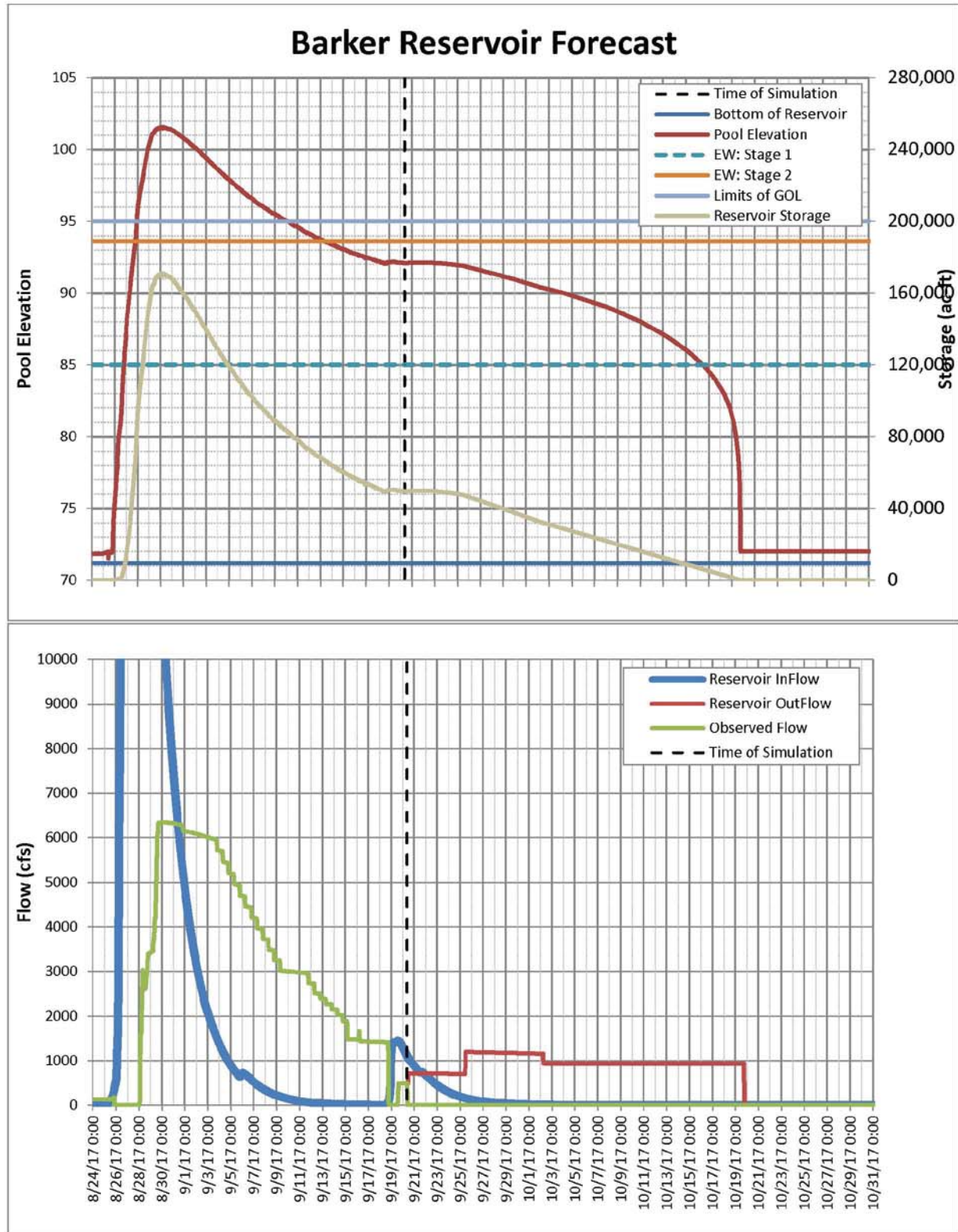
Page 3 of 4

Forecasted on:
20-Sep-17

USACE005995

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Galveston District

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CWMS Forecast: 9/21/2017

The Addicks and Barker watersheds have received trace amounts of rainfall in the last 24-hours. Gates are open at both reservoirs, releasing approximately 1400 cfs from Addicks and 700 cfs from Barker. The weather service is predicting a 20-50% chance of rain today through Monday, but the QPF is show accumulations of about half an inch of rain over the next 7-days.

The weather service has put out an advisory about the scattered showers and thunderstorms expected today. "Most areas may get up to a half inch of rain but there could be isolated higher amounts of 2-3" of rain... This will be similar to the rainfall we had on Monday afternoon." We will continue to monitor the weather radar and gauges through the day and will make the appropriate gate changes if necessary. This forecast assumes that discharges will be increased tomorrow and then again on Monday. With the currently forecasted discharges and no significant rain, the pool will be below Highway 6 (elevation 96.0) by Tuesday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

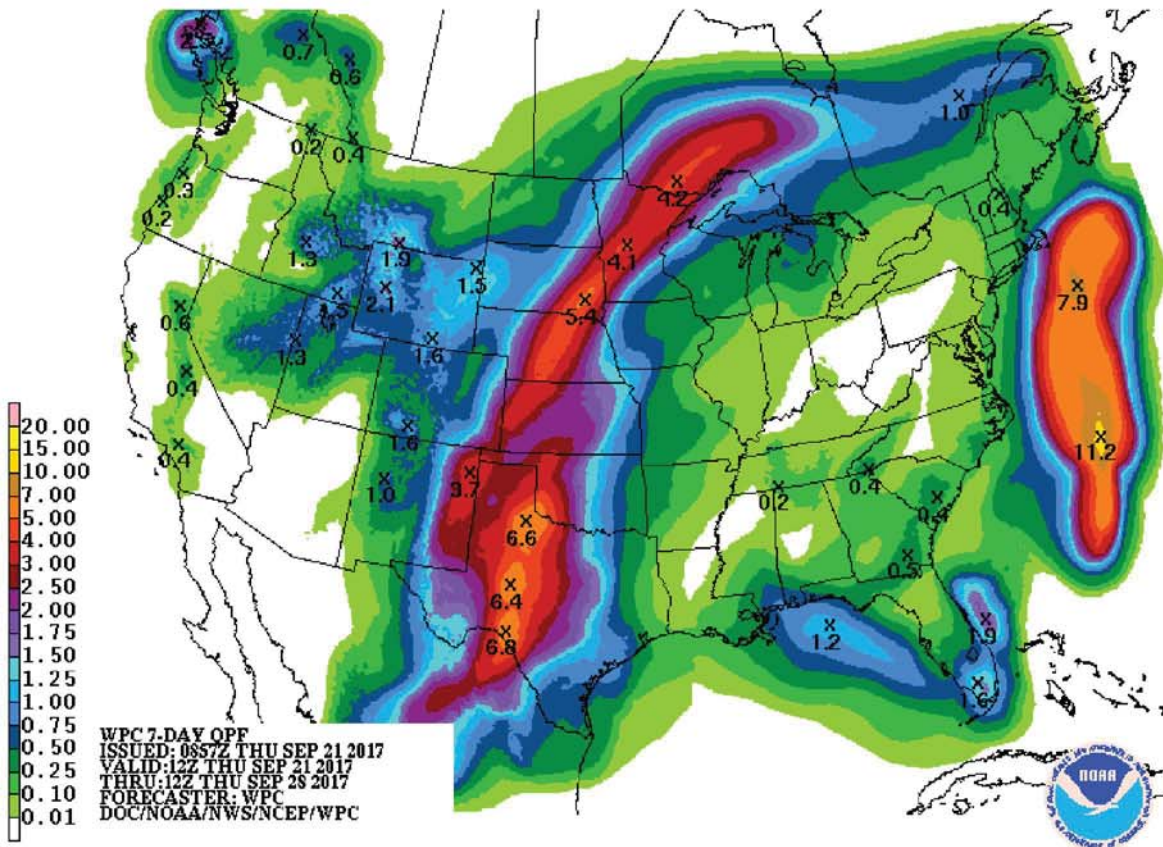
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | 3-4 weeks | 85 | 3-4 weeks |
| Empty | 67.5 | -4 weeks | 70.2 | -4 weeks |

Forecast Information:

- Forecast Start Time: 9/21/2017 07:00
- Lookback Period: 28 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 96.94 ft (NAVD88)
 - Barker: 91.96 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
21-Sep-17

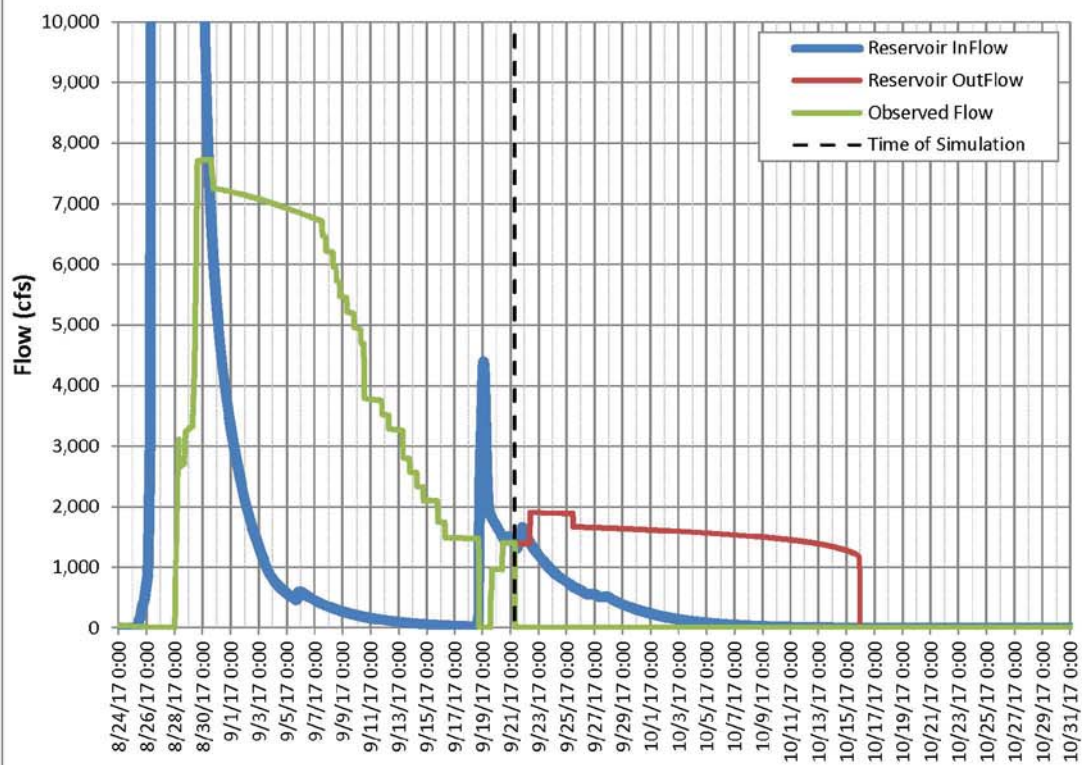
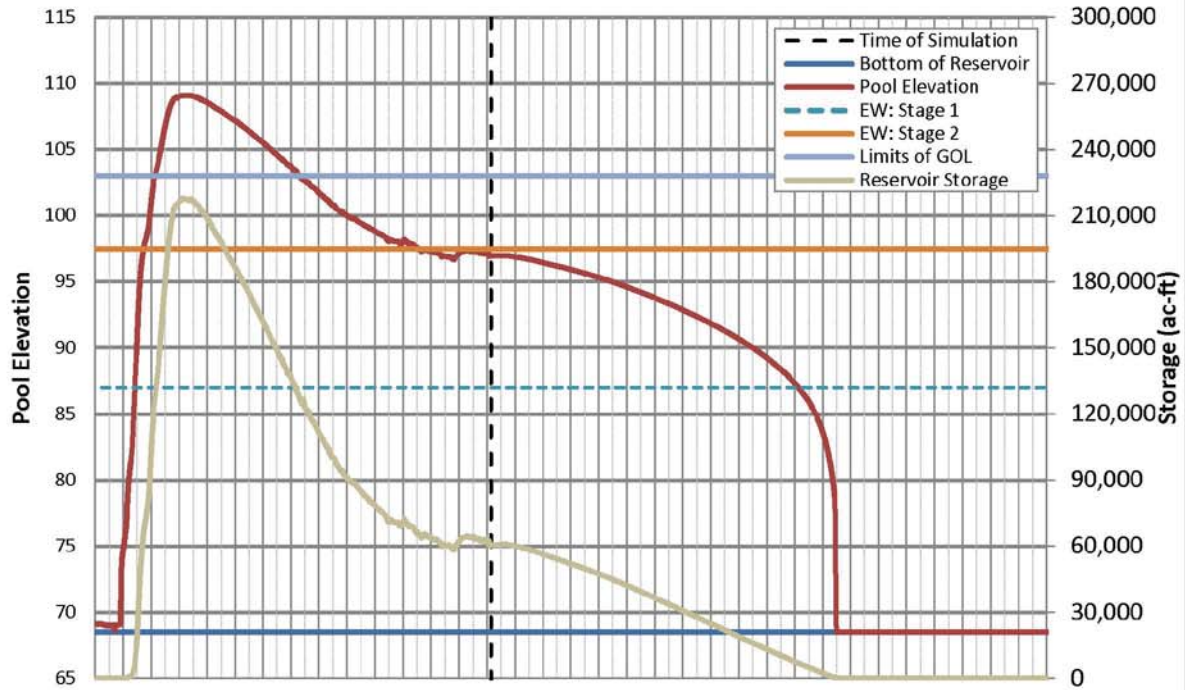
USACE005998

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

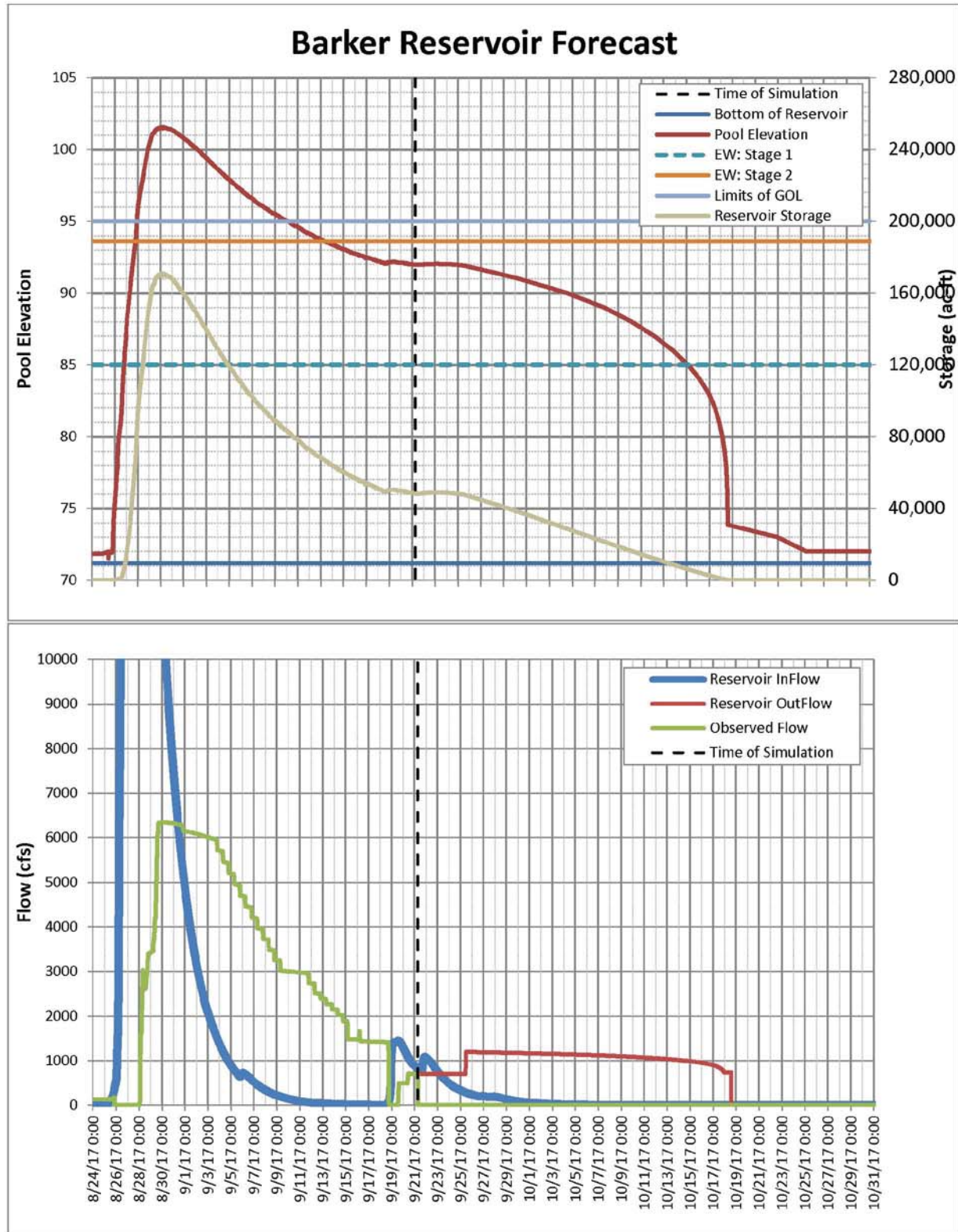
Page 3 of 4

Forecasted on:
21-Sep-17

USACE005999

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/22/2017

The Addicks and Barker watersheds received less than a half inch of rainfall yesterday. Gates are open at both reservoirs, releasing approximately 1400 cfs from Addicks and 900 cfs from Barker. The weather service is predicting a 20-40% chance of rain today through Thursday, but the QPF is show accumulations of about half an inch of rain over the next 7-days.

We are currently in the process of opening gates on Addicks to increase discharges there to approximately 2100 cfs. With the currently forecasted discharges and no significant rain, the pool will be below Eldridge Parkway (elevation 96.6) tomorrow and Highway 6 (elevation 96.0) by Monday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

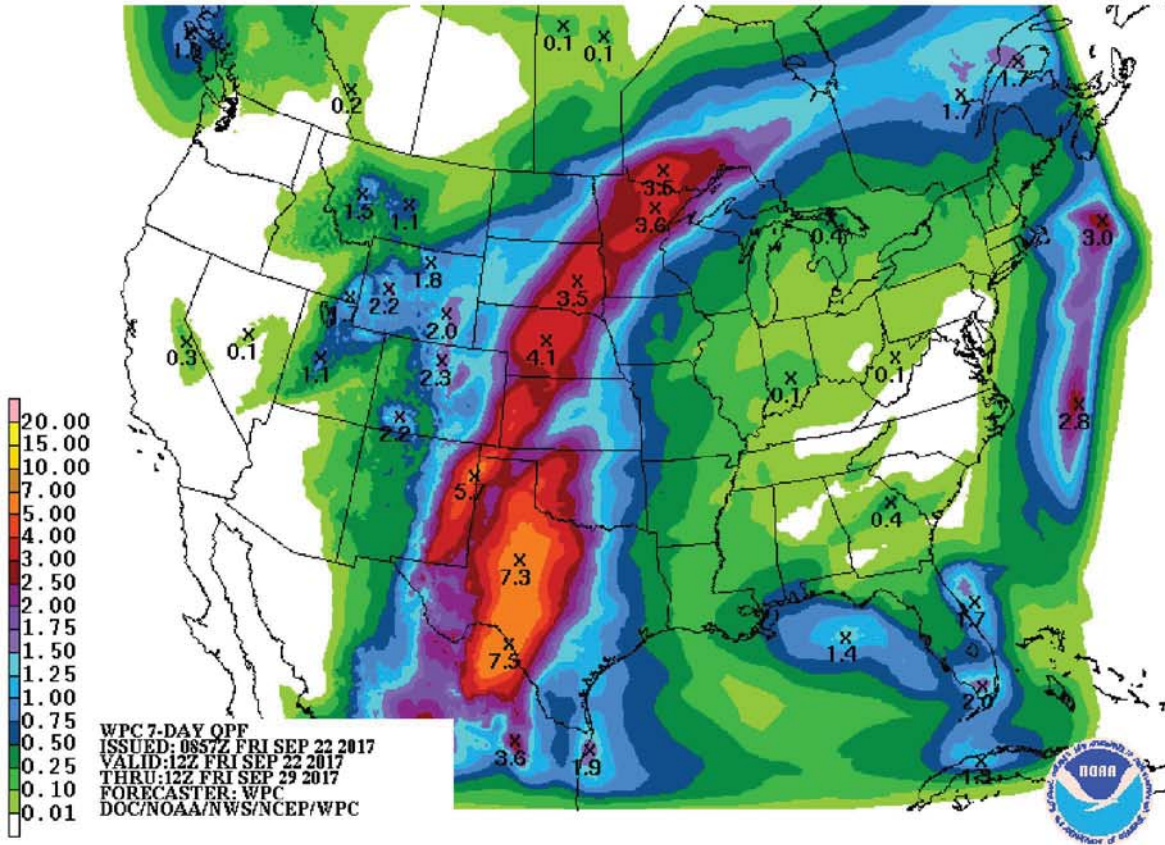
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | ~3 weeks | 85 | ~3 weeks |
| Empty | 67.5 | 3-4 weeks | 70.2 | 3-4 weeks |

Forecast Information:

- Forecast Start Time: 9/22/2017 09:00
- Lookback Period: 29 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 96.74 ft (NAVD88)
 - Barker: 91.83 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
22-Sep-17

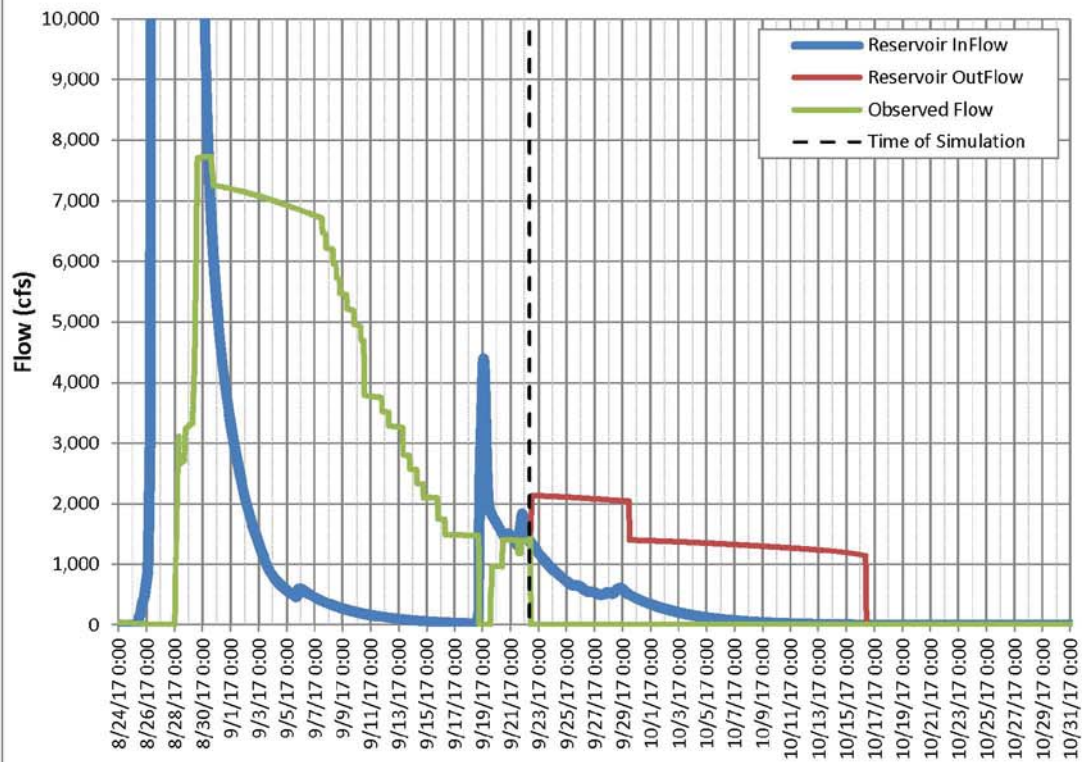
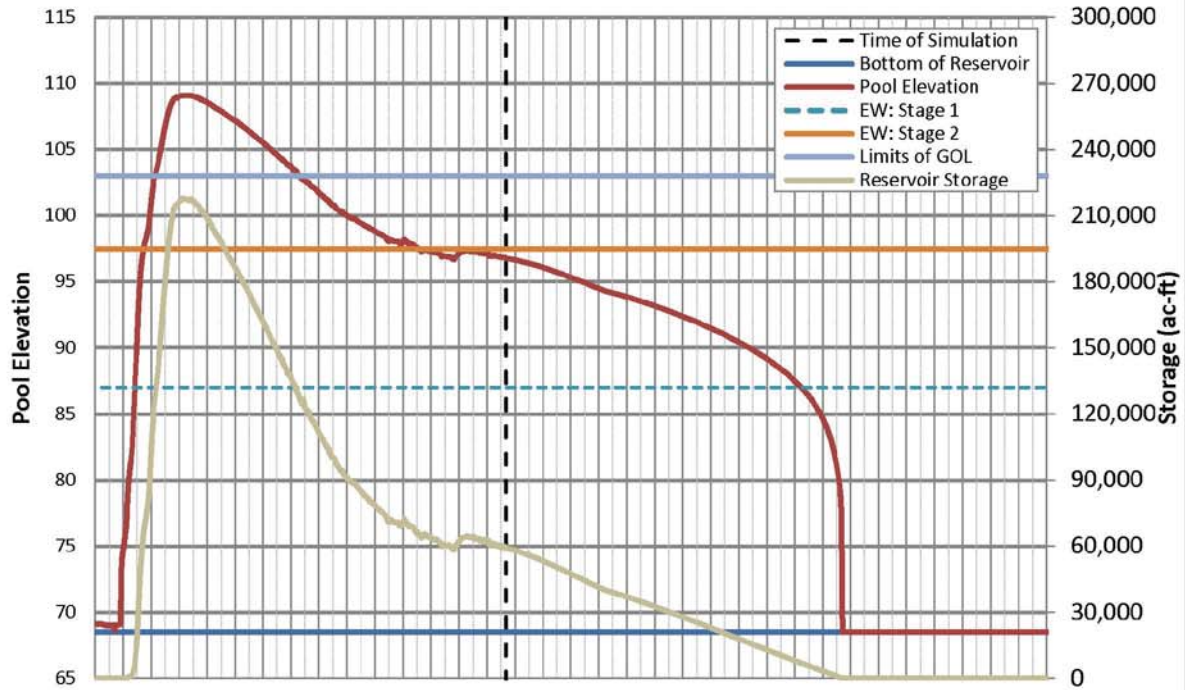
USACE006002

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

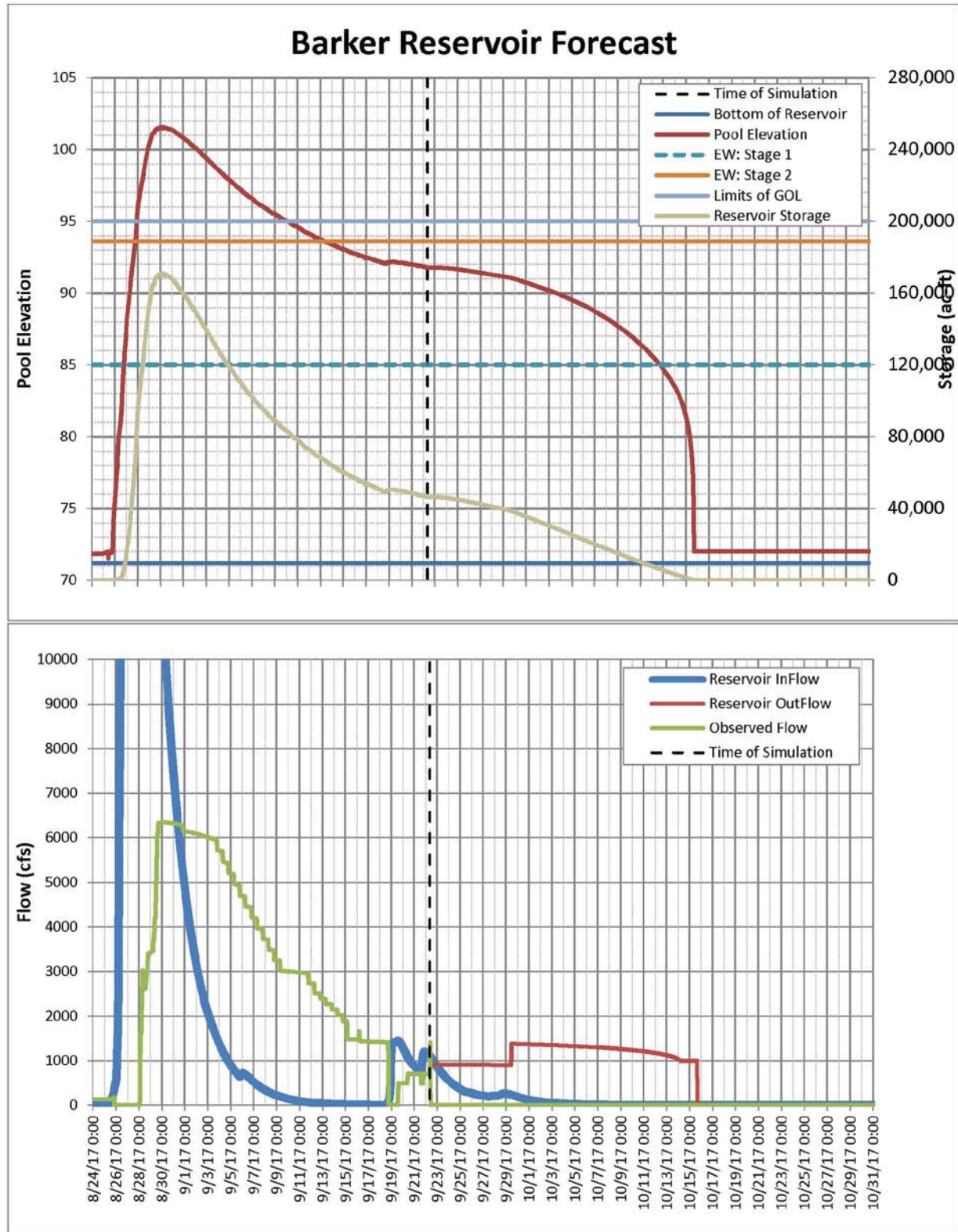
Page 3 of 4

Forecasted on:
22-Sep-17

USACE006003

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Galveston District

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CWMS Forecast: 9/25/2017

The Addicks and Barker watersheds only received trace amounts of rain over the weekend. Gates are open at both reservoirs, releasing approximately 2075 cfs from Addicks and 700 cfs from Barker. The weather service is predicting a 20-30% chance of rain today through Thursday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

Eldridge Parkway and Highway 6 are now open to traffic. At this time, we are planning on balancing the releases from the reservoirs on Wednesday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

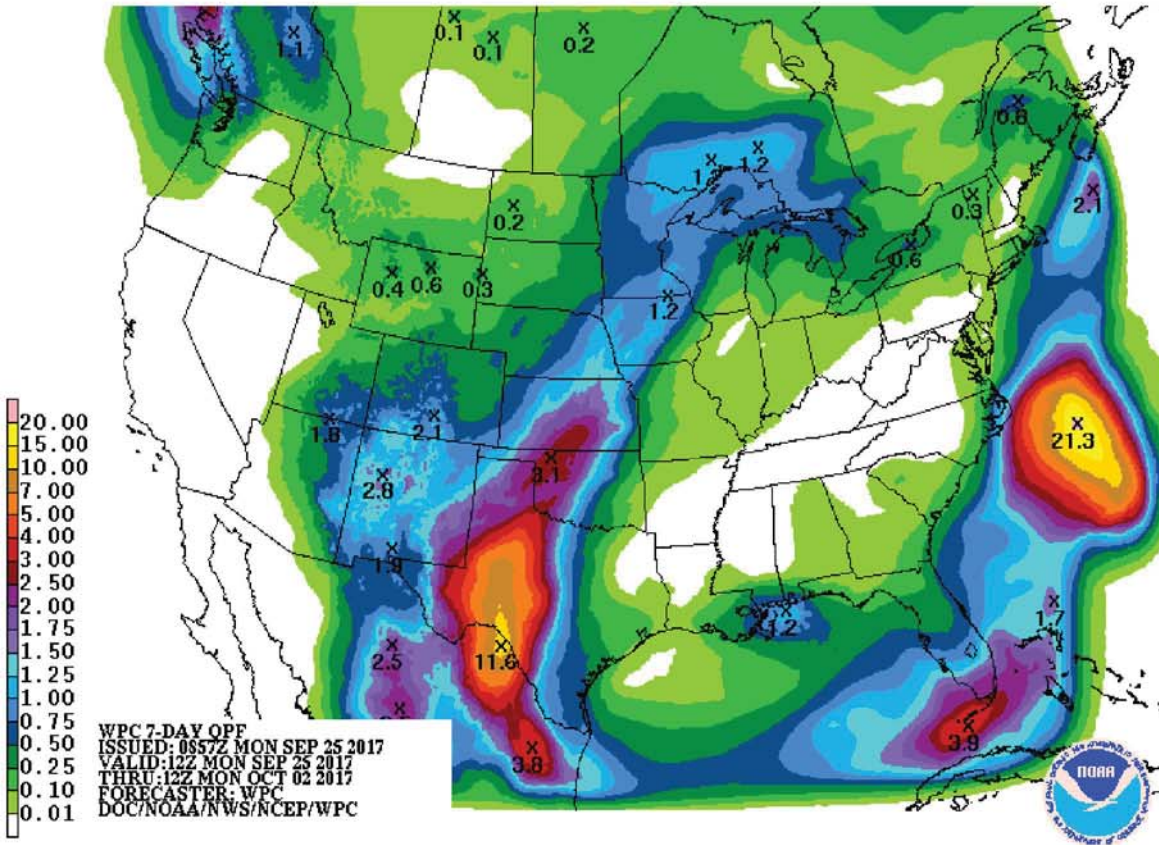
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | 2-3 weeks | 85 | 2-3 weeks |
| Empty | 67.5 | ~3 weeks | 70.2 | ~3 weeks |

Forecast Information:

- Forecast Start Time: 9/25/2017 09:00
- Lookback Period: 32 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 95.12 ft (NAVD88)
 - Barker: 91.37 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

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Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
25-Sep-17

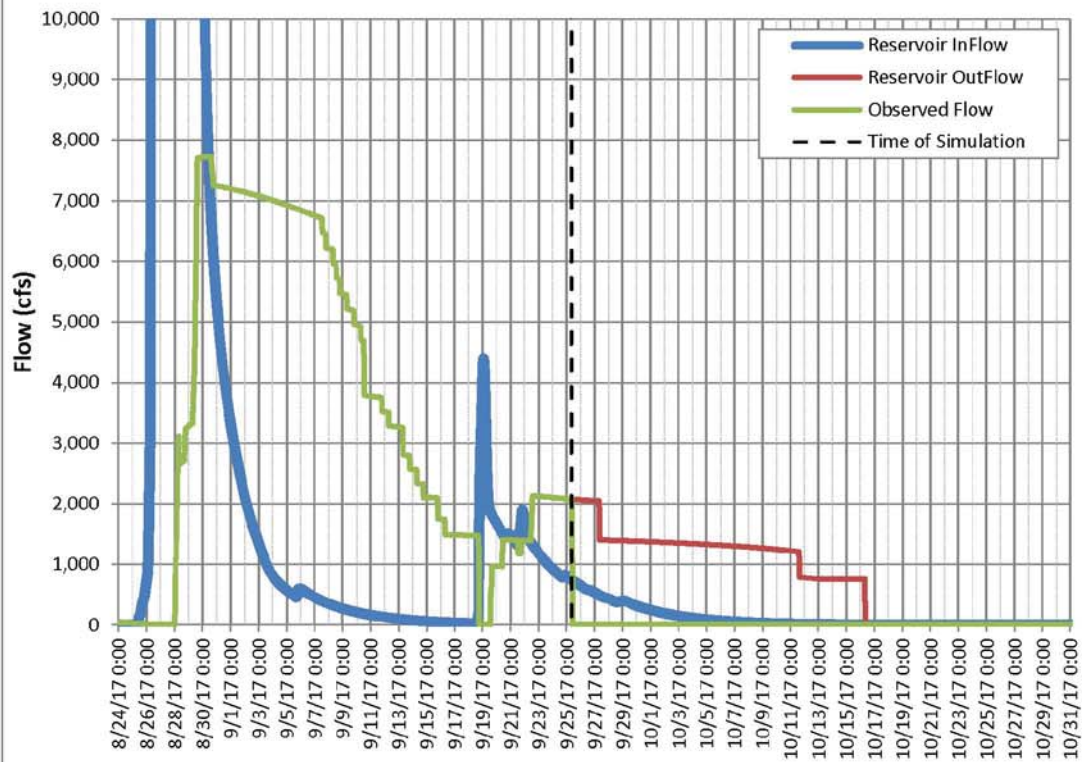
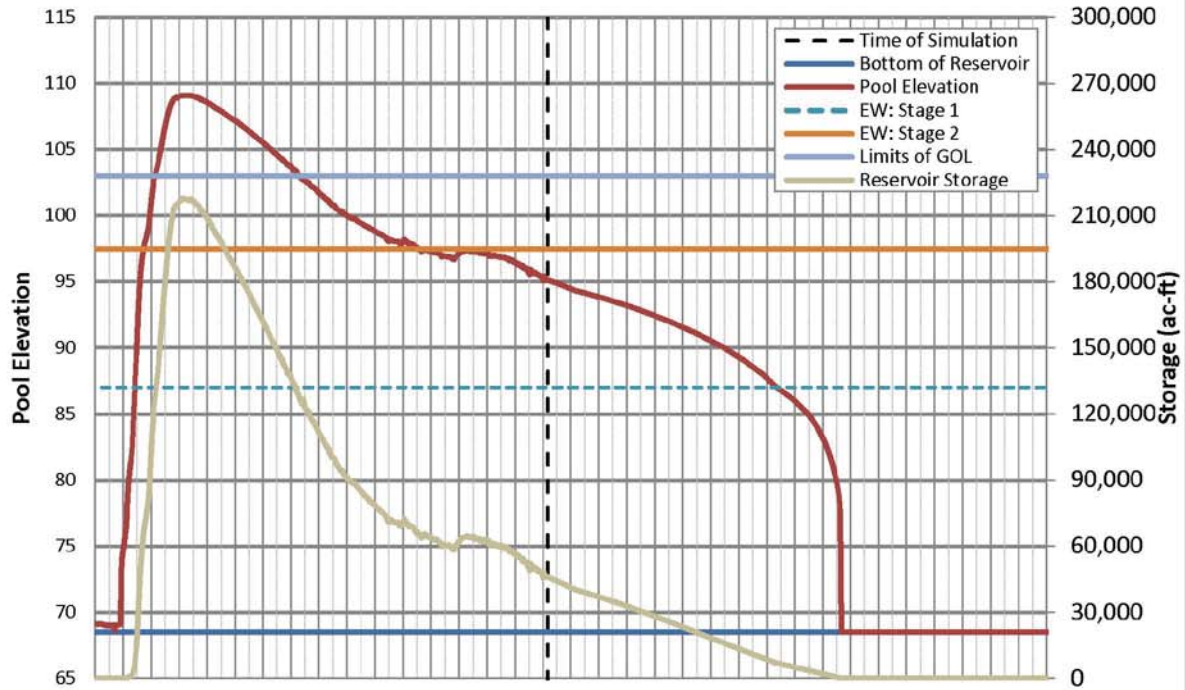
USACE006006

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

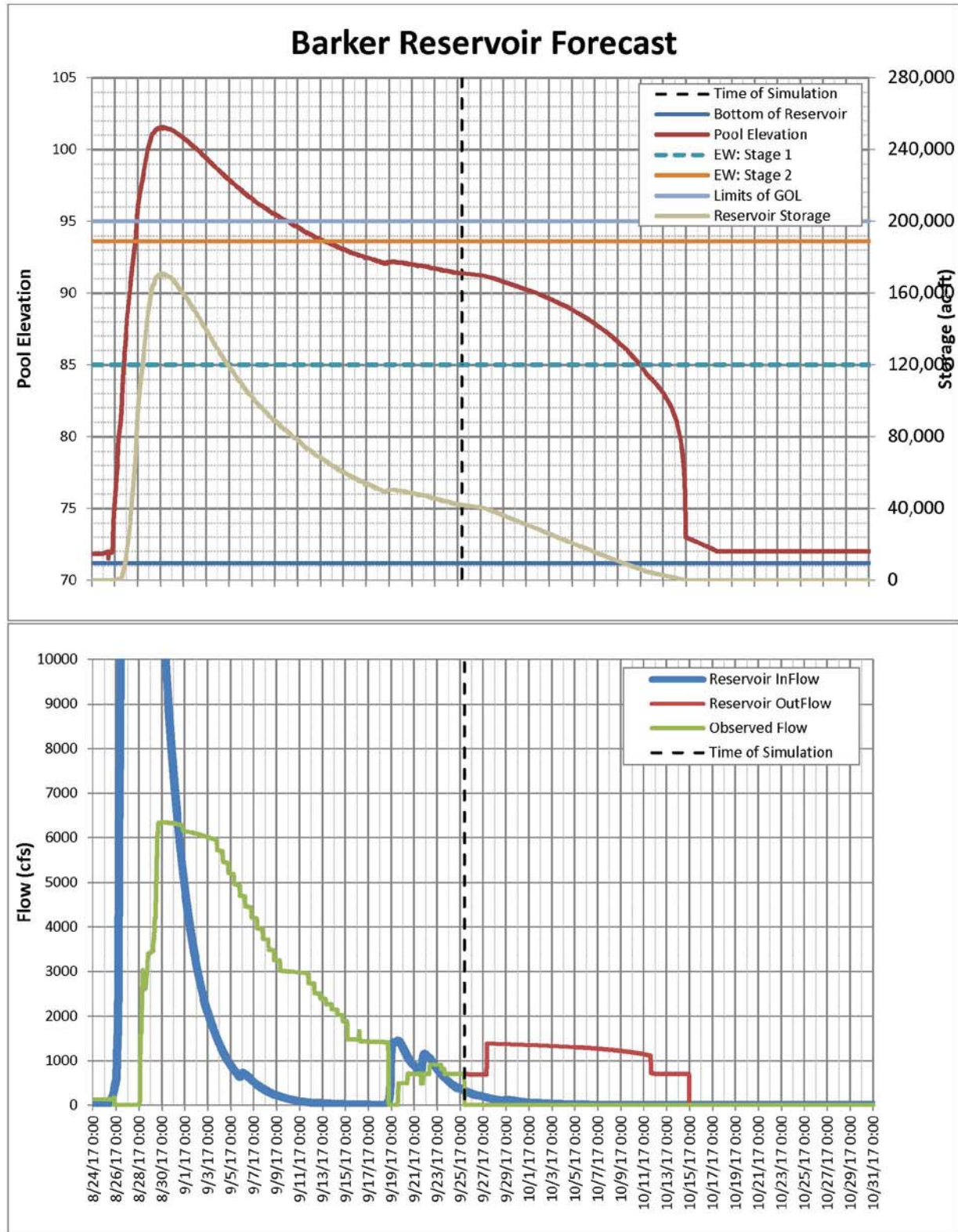
Page 3 of 4

Forecasted on:
25-Sep-17

USACE006007

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Galveston District

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CWMS Forecast: 9/26/2017

The Addicks and Barker watersheds only received trace amounts of rain over the last 24 hours. Gates are open at both reservoirs, releasing approximately 2050 cfs from Addicks and 700 cfs from Barker. The weather service is predicting a 20% chance of rain today through Thursday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

Eldridge Parkway and Highway 6 are now open to traffic. At this time, we are planning on adjusting the gate settings tomorrow so that the two reservoirs will be releasing close to 1400 cfs each.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

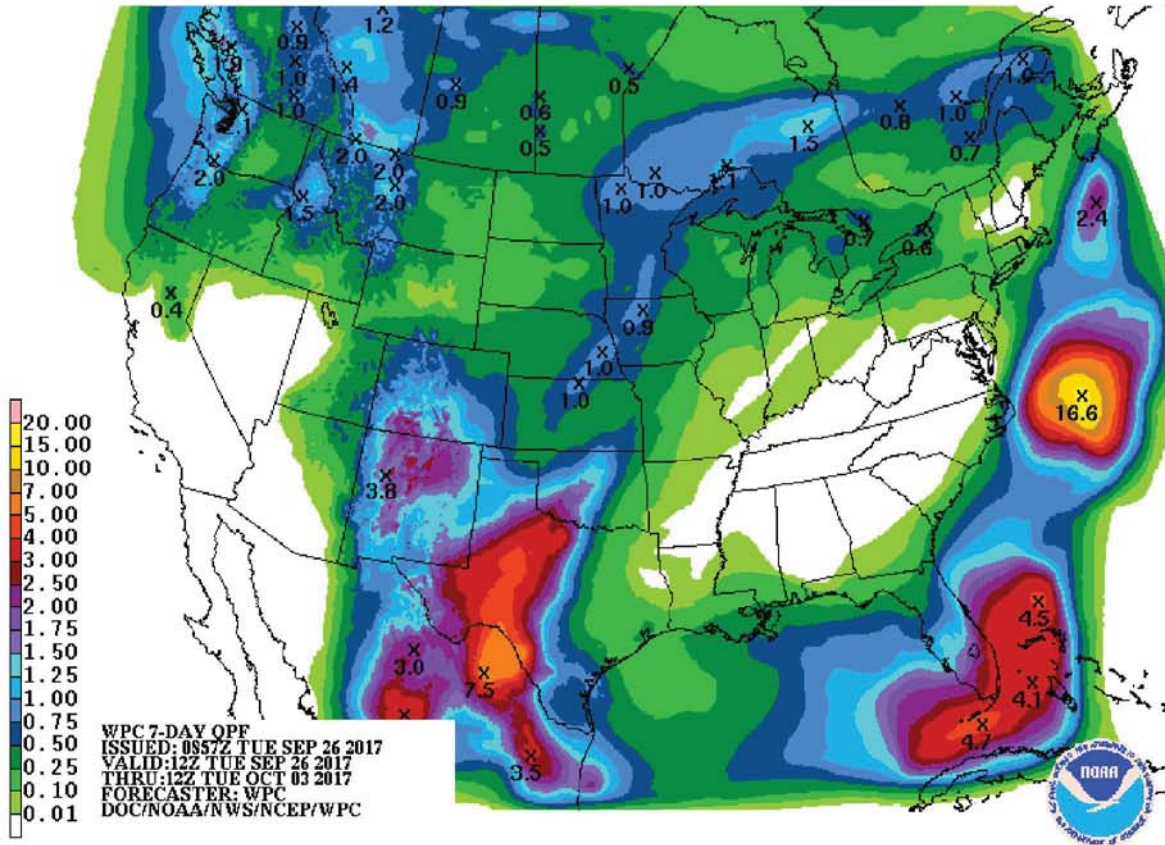
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | 2-3 weeks | 85 | 2-3 weeks |
| Empty | 67.5 | ~3 weeks | 70.2 | ~3 weeks |

Forecast Information:

- Forecast Start Time: 9/26/2017 07:00
- Lookback Period: 33 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 94.67 ft (NAVD88)
 - Barker: 91.25 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

Page 2 of 4

Forecasted on:
26-Sep-17

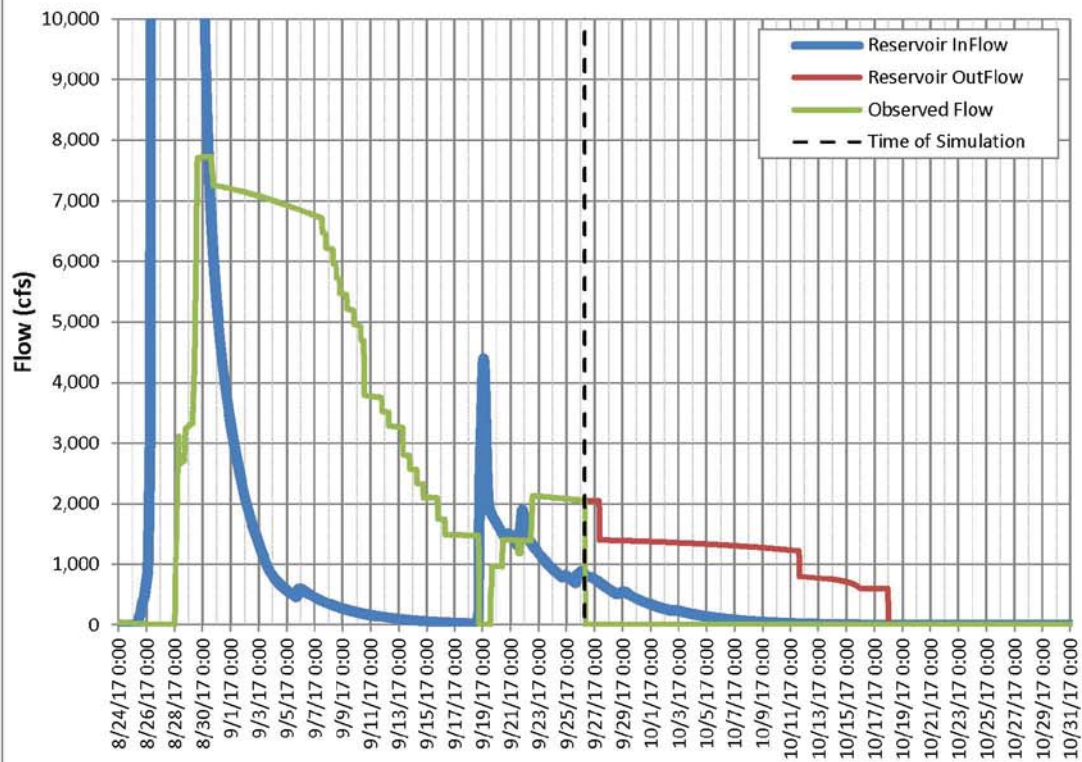
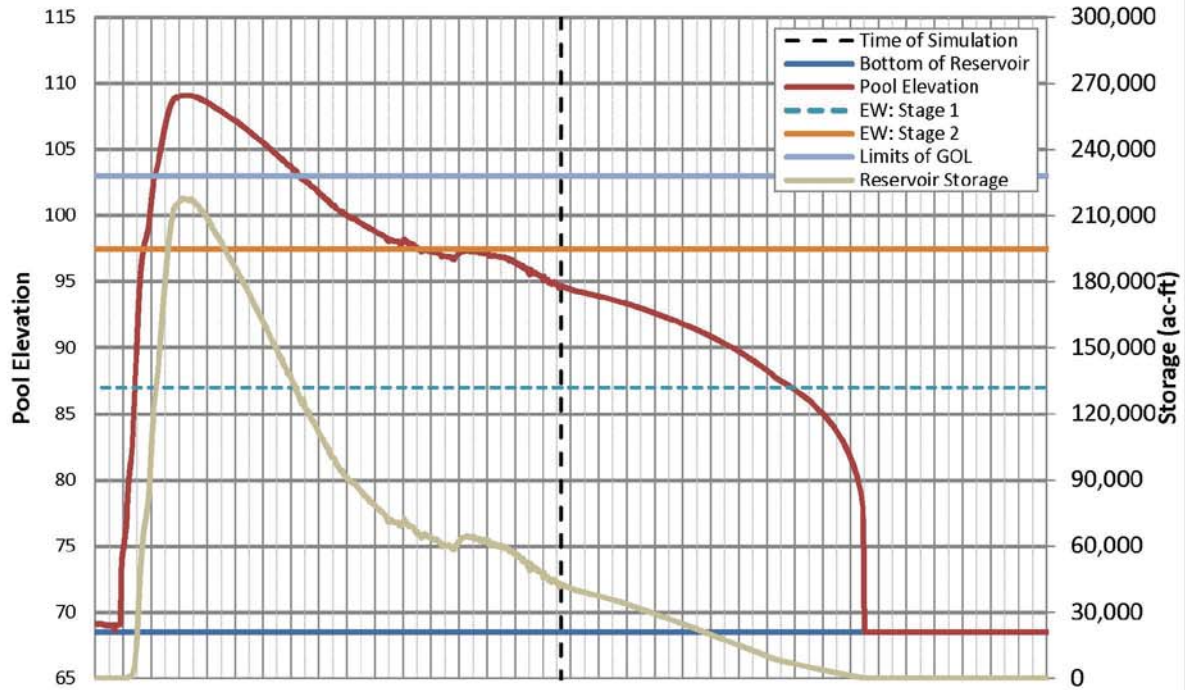
USACE006010

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

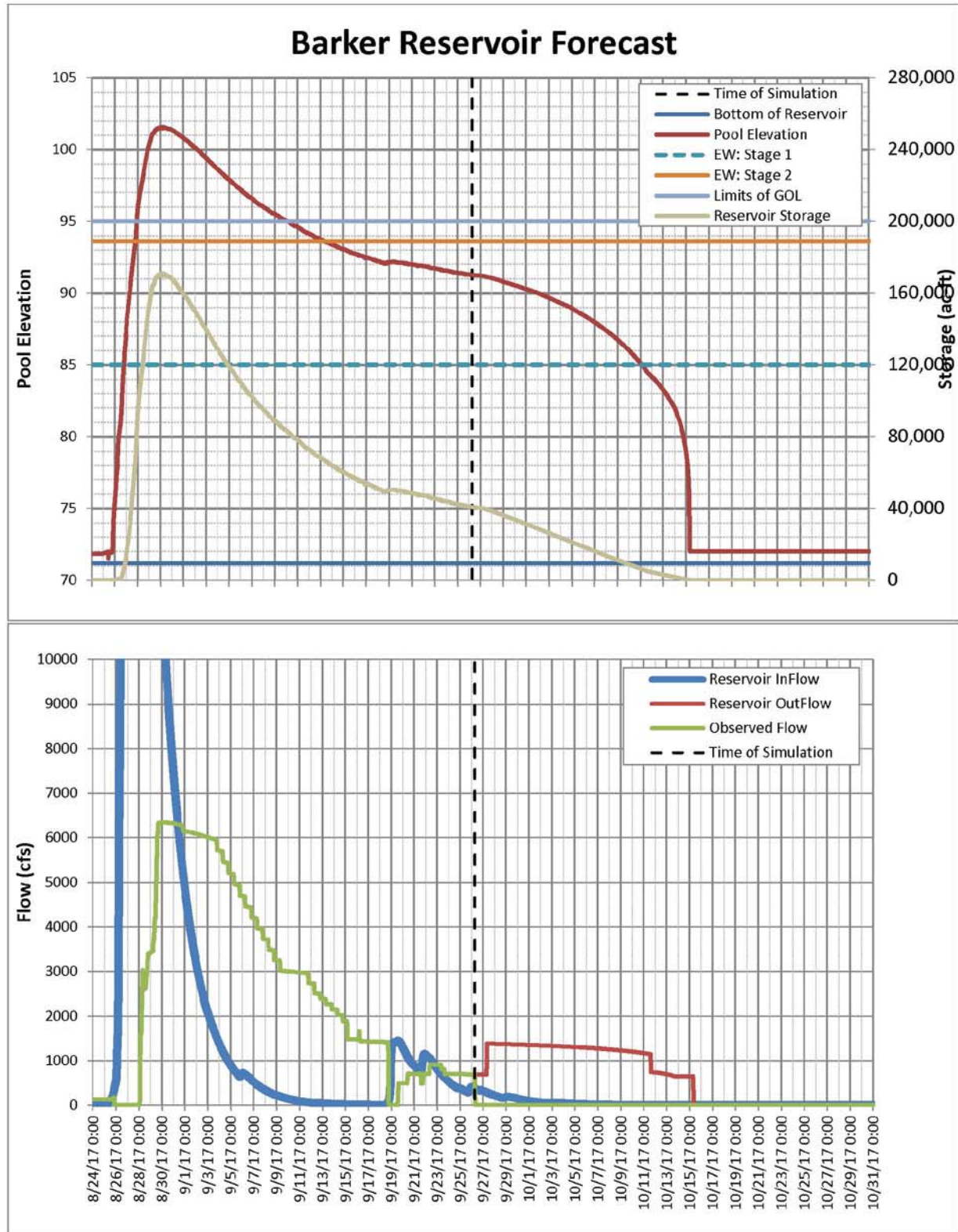
Page 3 of 4

Forecasted on:
26-Sep-17

USACE006011

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Galveston District

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CWMS Forecast: 9/27/2017

The Addicks watersheds received trace amounts of rain over the last 24 hours, however Barker received nearly half an inch over the whole watershed. Gates are open at both reservoirs, releasing approximately 2030 cfs from Addicks and 700 cfs from Barker. The weather service is predicting a 20-30% chance of rain today through Friday, but the QPF is show accumulations of less than half an inch of rain over the next 7-days.

At this time, we are planning on adjusting the gate settings this morning so that the two reservoirs will be releasing close to 1400 cfs each.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

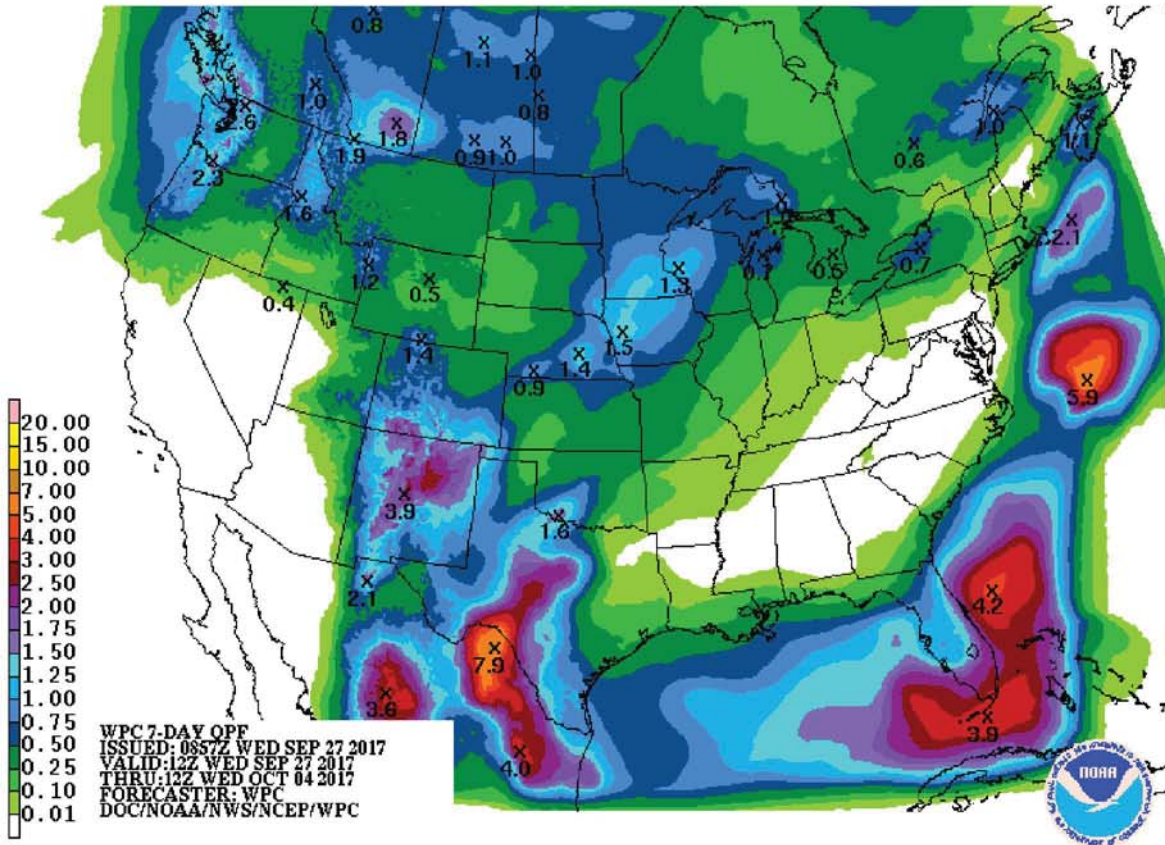
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|-------------------|--------|-------------------|
| | Addicks | | Barker | |
| Peak | 97.36 | 19 Sep 2017, 1400 | 92.17 | 19 Sep 2017, 1145 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | 15-17 days | 85 | 15-17 days |
| Empty | 67.5 | ~3 weeks | 70.2 | ~3 weeks |

Forecast Information:

- Forecast Start Time: 9/27/2017 07:00
- Lookback Period: 34 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 94.01 ft (NAVD88)
 - Barker: 91.31 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
27-Sep-17

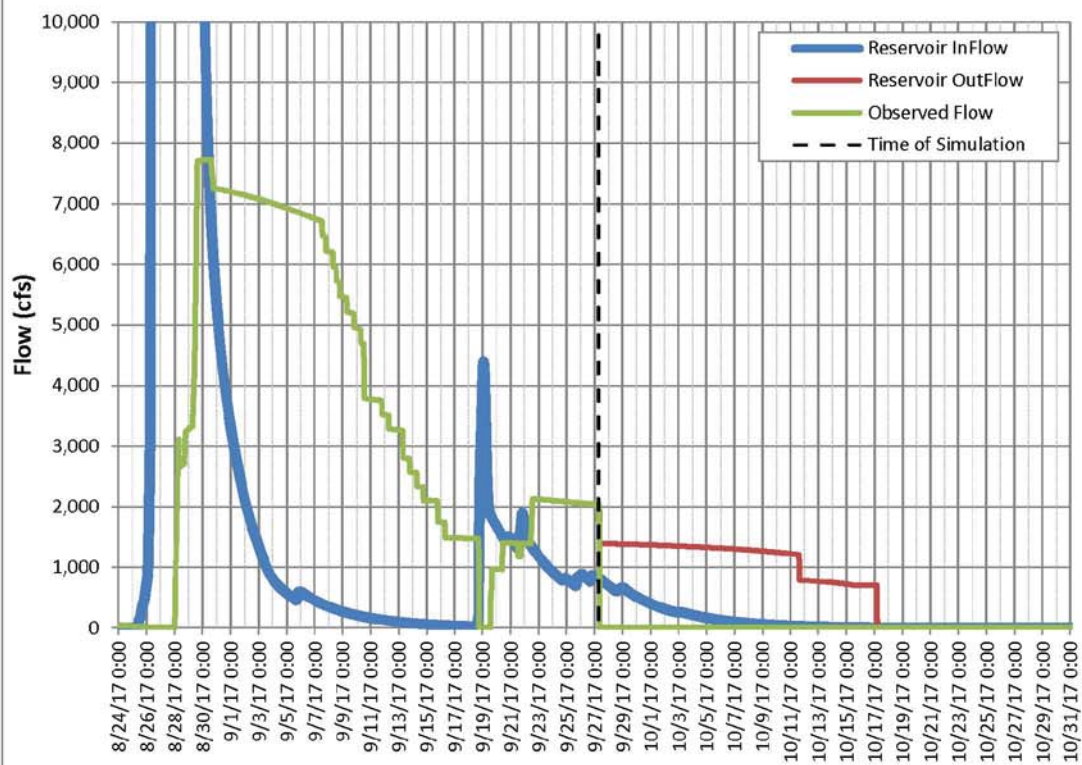
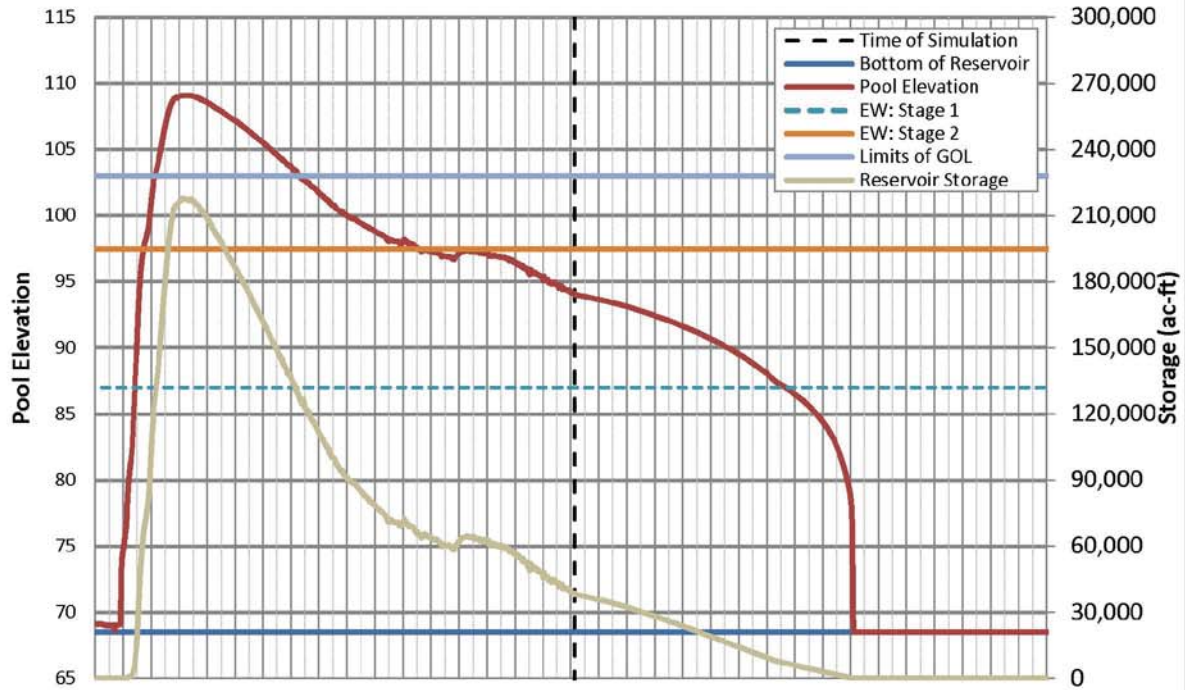
USACE006014

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M3ODXMGK

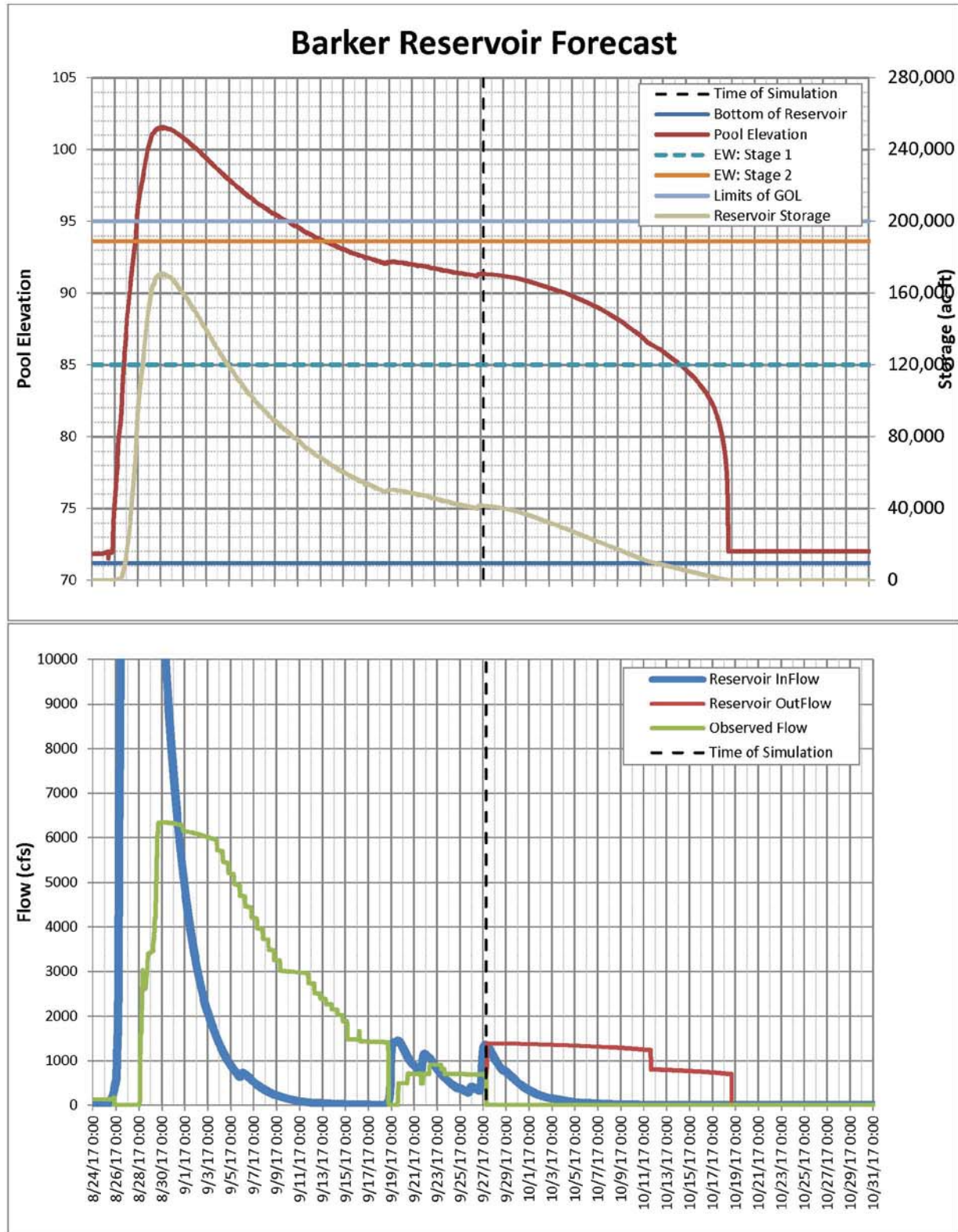
Page 3 of 4

Forecasted on:
27-Sep-17

USACE006015

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Galveston District

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CWMS Forecast: 9/28/2017

The Addicks and Barker watersheds have not received any rain in the last 24 hours. Gates are open at both reservoirs, releasing approximately 1380 cfs from both Addicks and Barker. The weather service is predicting a 30-40% chance of rain today and through the night, but the QPF is show accumulations of about half an inch of rain over the next 7-days.

This morning, we are planning on decreasing releases from Addicks to 1170 cfs and increasing releases from Barker to 1590 cfs.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

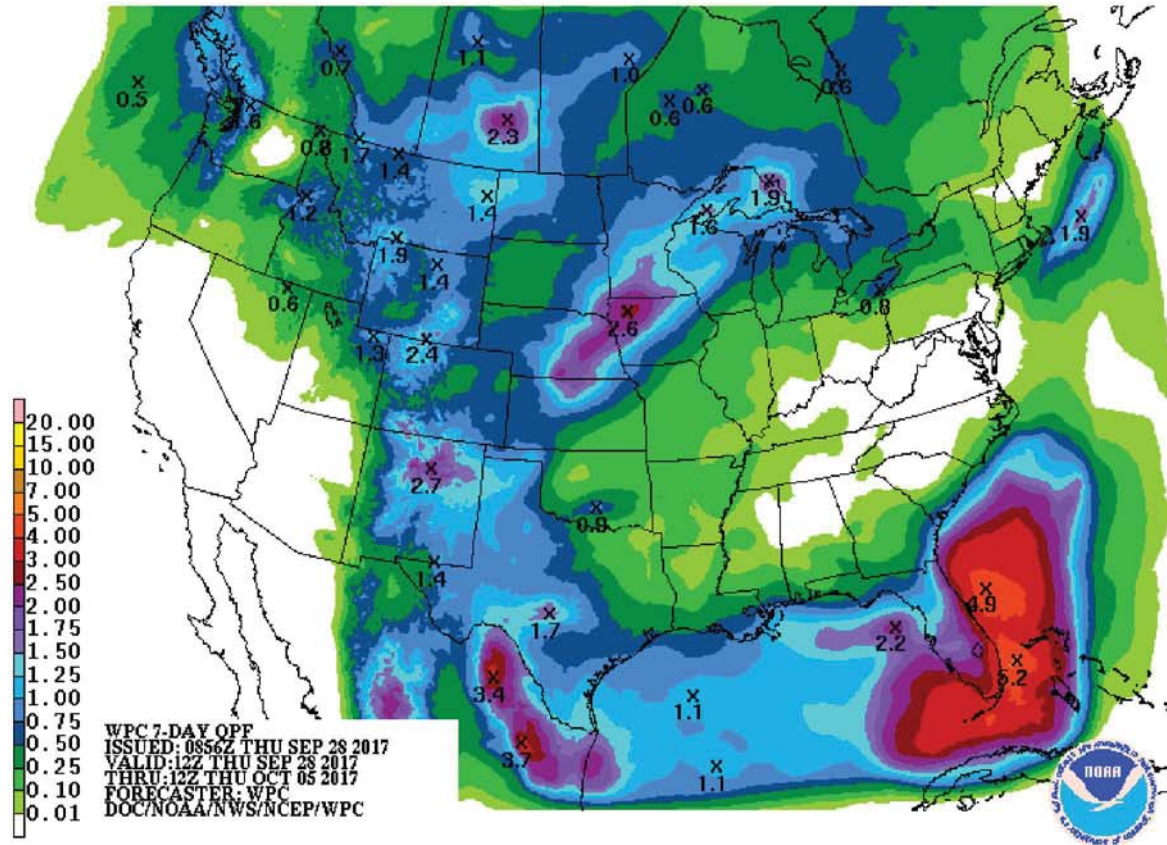
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | ~2 weeks | 85 | ~2 weeks |
| Empty | 67.5 | < 3 weeks | 70.2 | < 3 weeks |

Forecast Information:

- Forecast Start Time: 9/28/2017 07:00
- Lookback Period: 35 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 93.58 ft (NAVD88)
 - Barker: 91.04 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
28-Sep-17

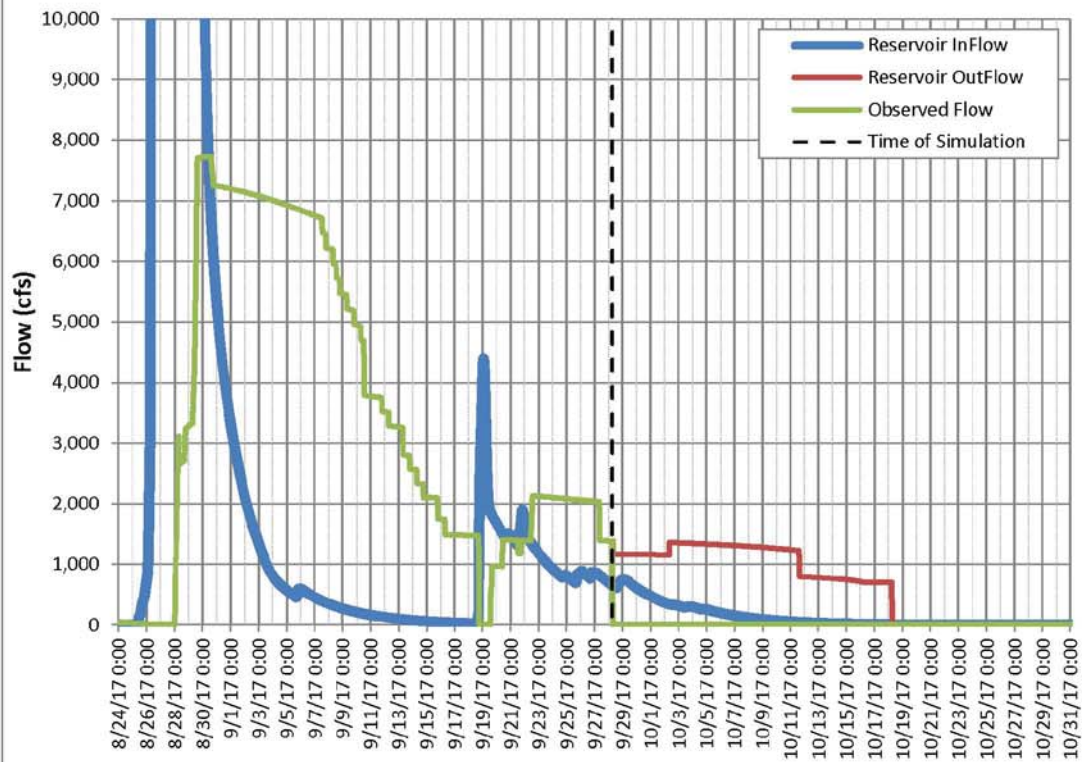
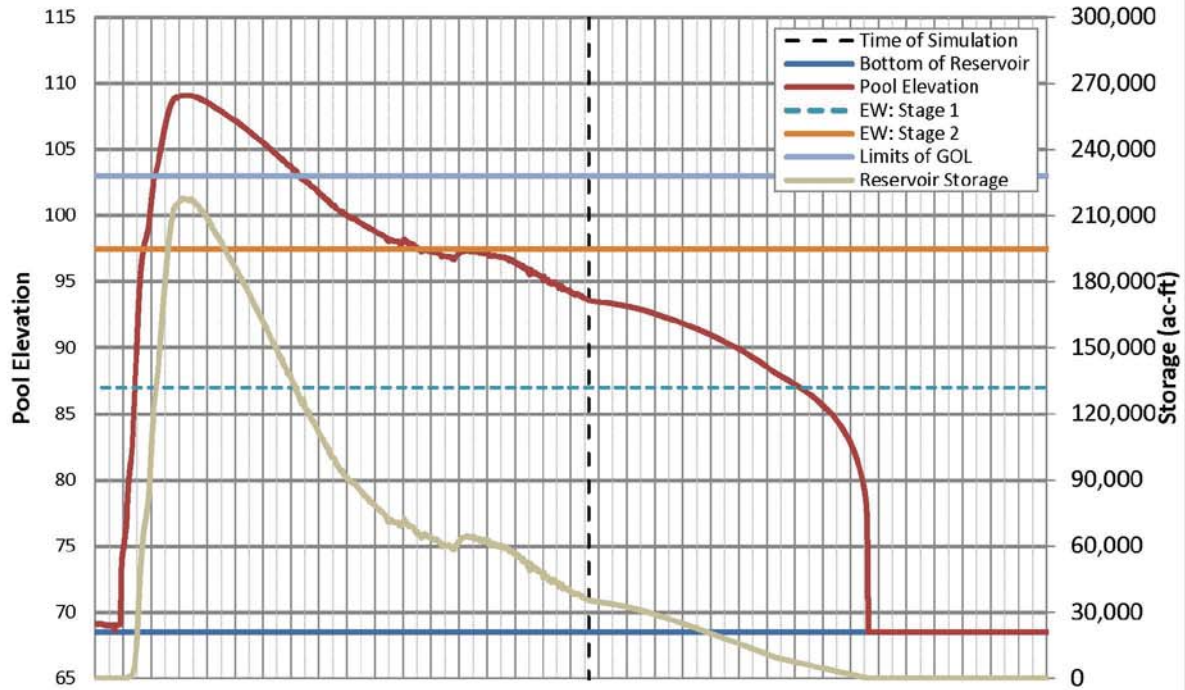
USACE006018

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Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

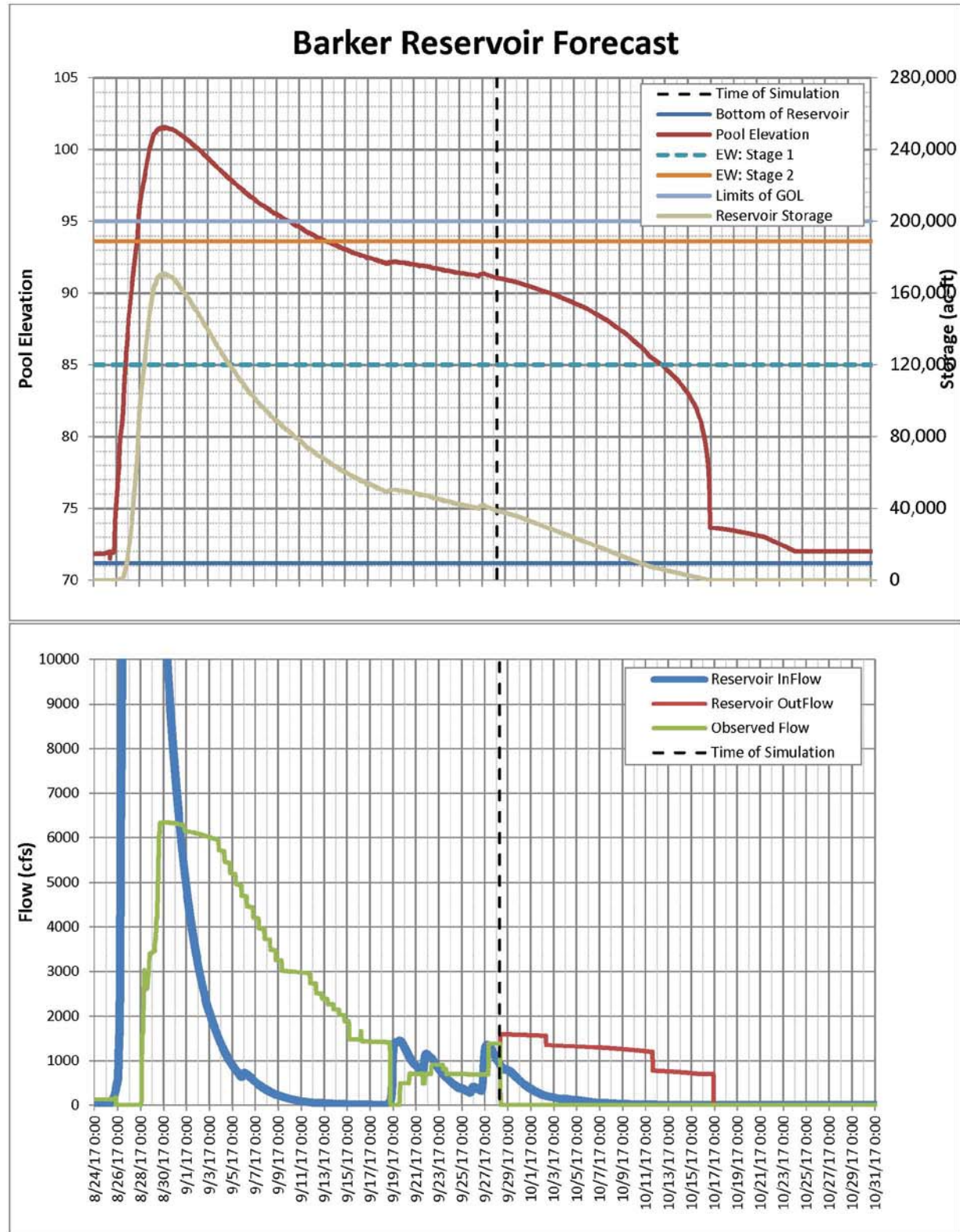
Page 3 of 4

Forecasted on:
28-Sep-17

USACE006019

U.S. Army Corps of Engineers
Galveston District

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CWMS Forecast: 9/30/2017

Addicks and Barker have not gotten any rain in the last 24 hours. The gates at both reservoirs are currently open and releasing approximately 1160 cfs from Addicks and 1570 cfs from Barker. The 7-day QPF is showing accumulations of about an inch of rain, with rain forecast on Monday-Wednesday.

The CWMS modeling suite is run when precipitation is anticipated to help plan reservoir operations. Updated reservoir forecasts will be provided if NOAA substantially changes its precipitation forecast.

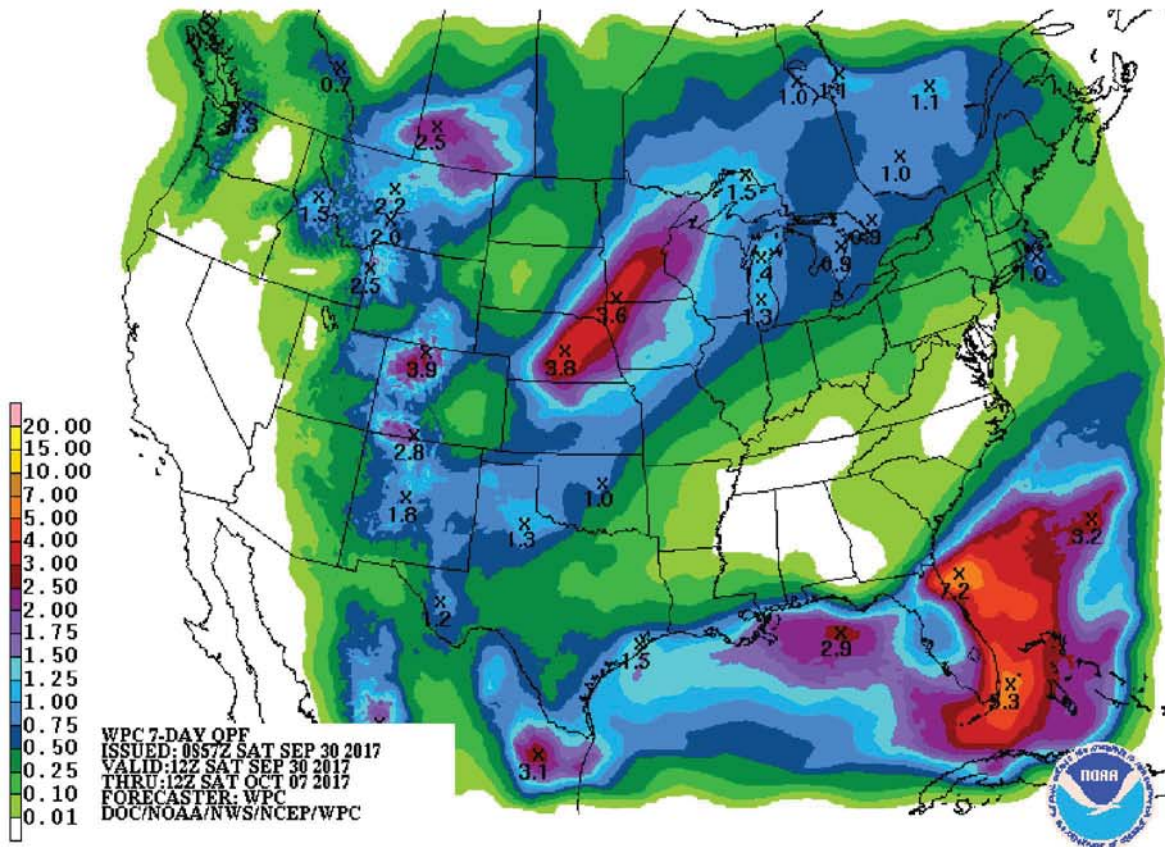
| Forecast Summary for QPF | | | | |
|-------------------------------|---------|--------------------|--------|--------------------|
| | Addicks | | Barker | |
| Peak | 109.09 | 30 Aug 2017, 07:00 | 101.56 | 30 Aug 2017, 06:00 |
| EW, Stage 2 Res. Level | 97.46 | Not forecasted | 93.6 | Not forecasted |
| EW, Stage 1 Res. Level | 87 | ~2 weeks | 85 | ~2 weeks |
| Empty | 67.5 | < 3 weeks | 70.2 | < 3 weeks |

Forecast Information:

- Forecast Start Time: 9/30/2017 05:00
- Lookback Period: 37 days
- Forecast End Time: 10/31/2017
- Data Sources
 - NexRad
 - Gridded QPF
- Starting reservoir elevations
 - Addicks 92.96 ft (NAVD88)
 - Barker: 90.46 ft (NAVD88)
- Predicted reservoir flows shown on Pages 3 & 4
- Predicted discharges available on request

U.S. Army Corps of Engineers
Galveston District

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7-day QPF

Forecasted by:
M30DXMGK

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Forecasted on:
30-Sep-17

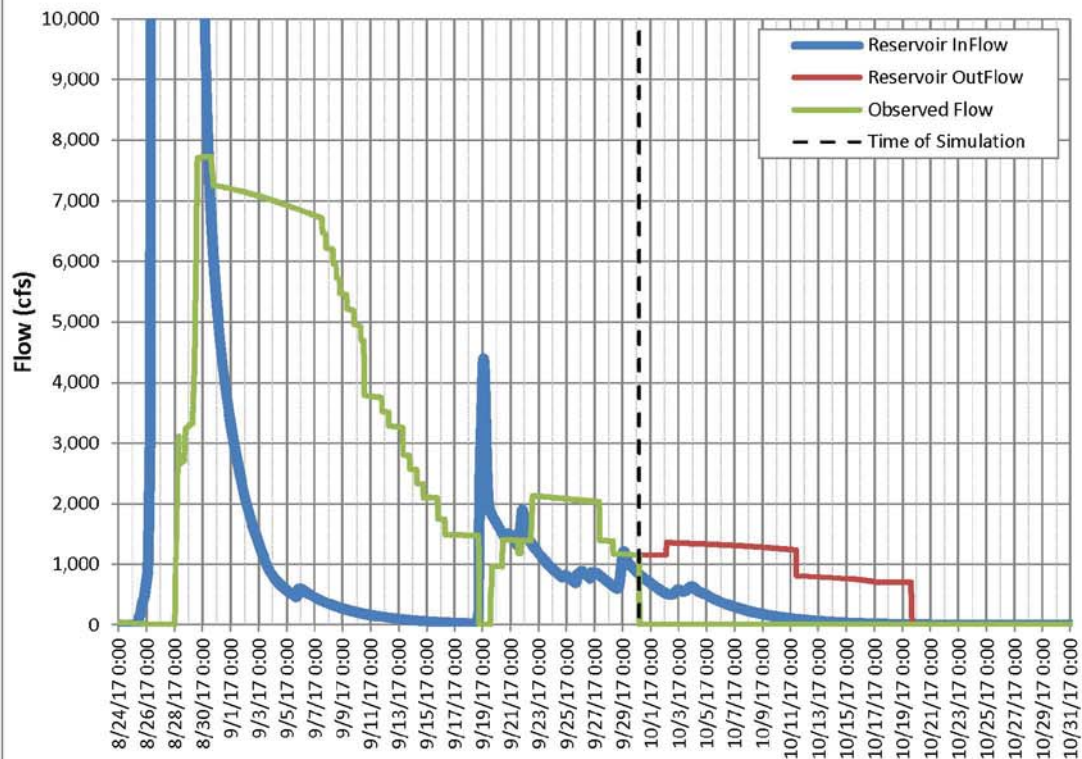
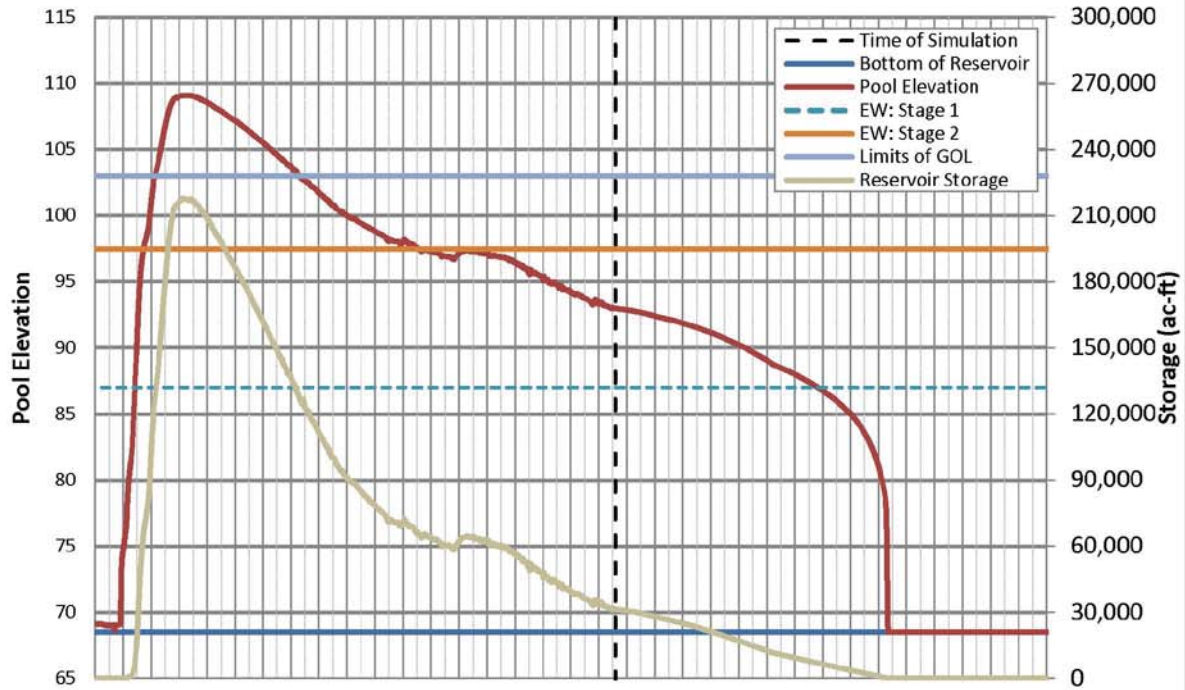
USACE006022

U.S. Army Corps of Engineers
Galveston District

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Addicks Reservoir Forecast



Forecasted by:
M30DXMGK

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Forecasted on:
30-Sep-17

USACE006023

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Galveston District

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